# The Art of Igniting the SAT Revolution

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The Art of SAT Shonan Meeting

October 2, 2023, Shonan Village Center, Japan

extended version of POS'23 @ SAT'23 talk

The SAT Museum

# Goal

It has been stated that

> “No major performance breakthrough [in SAT solving] in close to two decades”

where notable proponents of this claim are

- Karem Sakallah at the recent Simons Institute’s seminar in 2023
- João Marques-Silva during his invited talk at POS’19

The SAT Museum exists to document the history of SAT solving and
to show in contrast to these claims that indeed

> “SAT solvers are getting faster and faster”

and thus document how to **ignite the art of SAT solving**

# Motivation

- assess progress of SAT solving in the last decades
- **25** all-time-winners of SAT Competitions (1992, **1995**, 2002 - 2022, **2023**)
  - application / main track
- plus versions of historically interesting solvers
  - Grasp, Chaff, zChaff, Siege, MiniSAT, PicoSAT, CaDiCaL
- apple-to-apple comparison on same hardware / software
- competition instances from 7 years: 2002, 2011, 2019, 2020, 2021, 2022, **2023**
  - again only application / main track
  - not merged so compared separately per year
    no need to remove duplicates
- collect and patch solvers

**new not yet presented results**

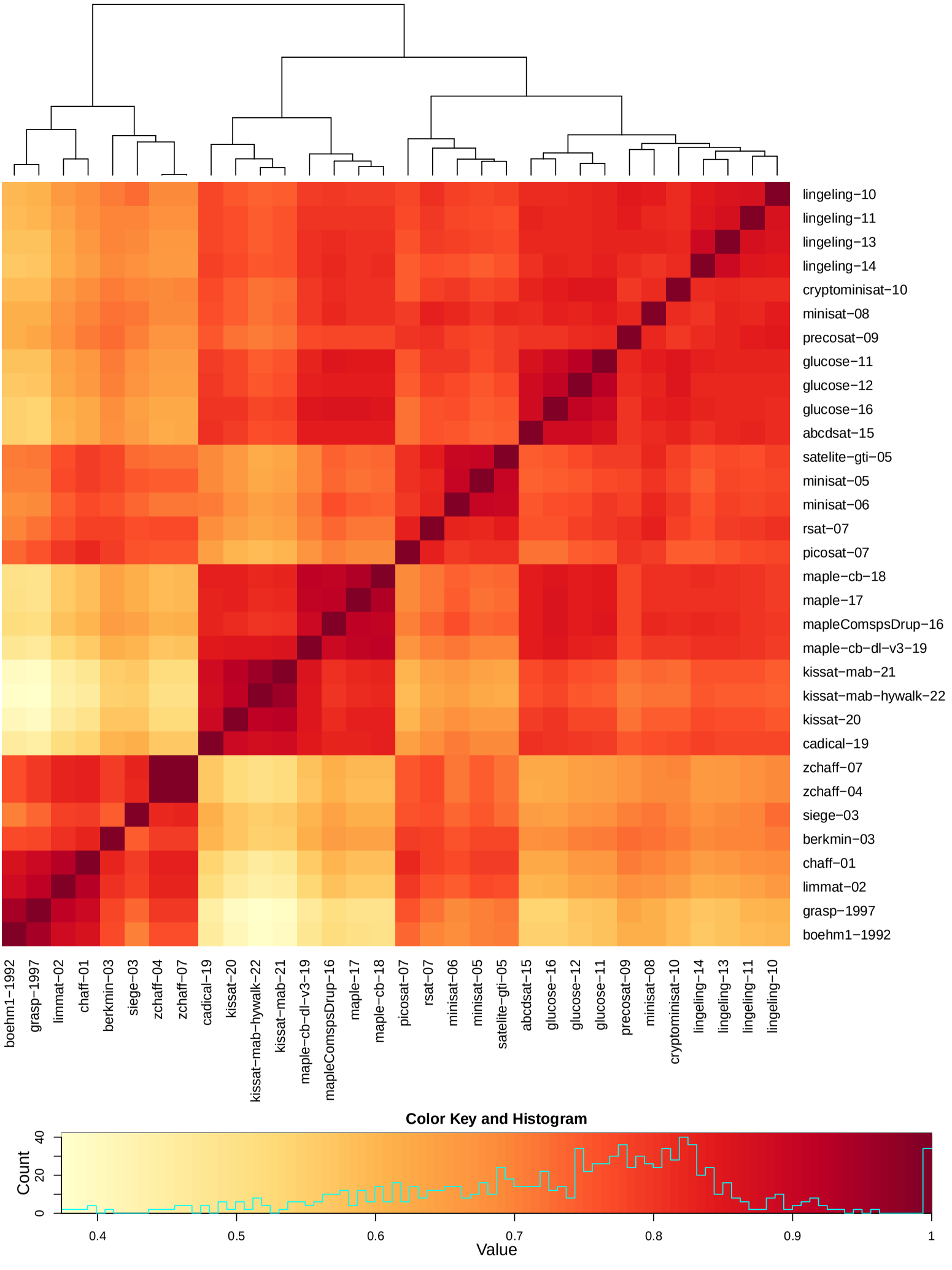
# Solvers Features - 1st Decade

- Before Preprocessing
  - DPLL solvers boehm1-1992, **posit-1995**
  - seminal CDCL solvers grasp-1997, chaff-2001, zchaff-200[147]
  - (almost) winners limmat-2002, siege-2003 (vmtf), berkmin-2003
  - SAT'22 test-of-time awardee minisat-200[5678] incl. minimization

    note however that the MiniSat paper is from 2003
- With Preprocessing
  - seminal preprocessing solver satelite-gti-2005 (SatElite + MiniSAT)
  - added phase saving and rapid restarts rsat-2007
  - LBD and better restarts in glucose-20$\{$11,12,16$\}$

# Solvers Features - 2nd Decade

- With Inprocessing
  - first inprocessing solvers precosat-2009, cryptominisat-2010
  - advanced inprocessing in lingeling-201[0134], abcdsat-2015
- With Mode Switching (stable mode for SAT, focused mode for UNSAT)
  - maple-comsps-drup-2016 (plus LRB and reason-side bumping),
    maple-lcm-dist-2017 (vivification),
    maple-lcm-dist-cb-2018 (chronological backtracking) and
    maple-lcm-disc-cb-dl-v3-2019 (hashing) each by different sets of authors
- Local Search / Target Phases
  - cadical-2019 (target phases) was improved and optimized in kissat-2020
  - kissat-mab-2021 (stable decisions), kissat-mab-hywalk-2022 (random walks)
- **Latest winning solver sbva-cadical-2023 (with bounded variable edition)**


lingeling−10
lingeling−11
lingeling−13
lingeling−14
cryptominisat−10
minisat−08
precosat−09
glucose−11
glucose−12
glucose−16
abcdsat−15
satelite−gti−05
minisat−05
minisat−06
rsat−07
picosat−07
maple−cb−18
maple−17
mapleComspsDrup−16
maple−cb−dl−v3−19
kissat−mab−21
kissat−mab−hywalk−22
kissat−20
cadical−19
zchaff−07
zchaff−04
siege−03
berkmin−03
chaff−01
limmat−02
grasp−1997
boehm1−1992
boehm1−1992
grasp−1997
limmat−02
chaff−01
berkmin−03
siege−03
zchaff−04
zchaff−07
cadical−19
kissat−20
kissat−mab−hywalk−22
kissat−mab−21
maple−cb−dl−v3−19
mapleComspsDrup−16
maple−17
maple−cb−18
picosat−07
rsat−07
minisat−06
minisat−05
satelite−gti−05
abcdsat−15
glucose−16
glucose−12
glucose−11
precosat−09
minisat−08
cryptominisat−10
lingeling−14
lingeling−13
lingeling−11
lingeling−10
Color Key and Histogram
Count
0
20
40
0.4
0.5
0.6
0.7
0.8
0.9
1
Value

# Patches

- binary only solvers siege-2003, berkmin-2003, abcdsat-2015
- collected original source code and provided patches:

```
satmuseum/solvers$ wc -l */*patch*|tail -1
  9758 total
```

  - including proper build environment (makefiles)
  - oldest solvers required largest effort
    for grasp-1997 we started with patched version from João dated 2008
- typical MiniSat patches (formatting, default argument, friend)
- several solvers had hard coded line buffers or maximum clause size
  silently truncate longer clauses
- also had to provide patches to make solver 64-bit clean
  some where trivial and some hard to find and fix

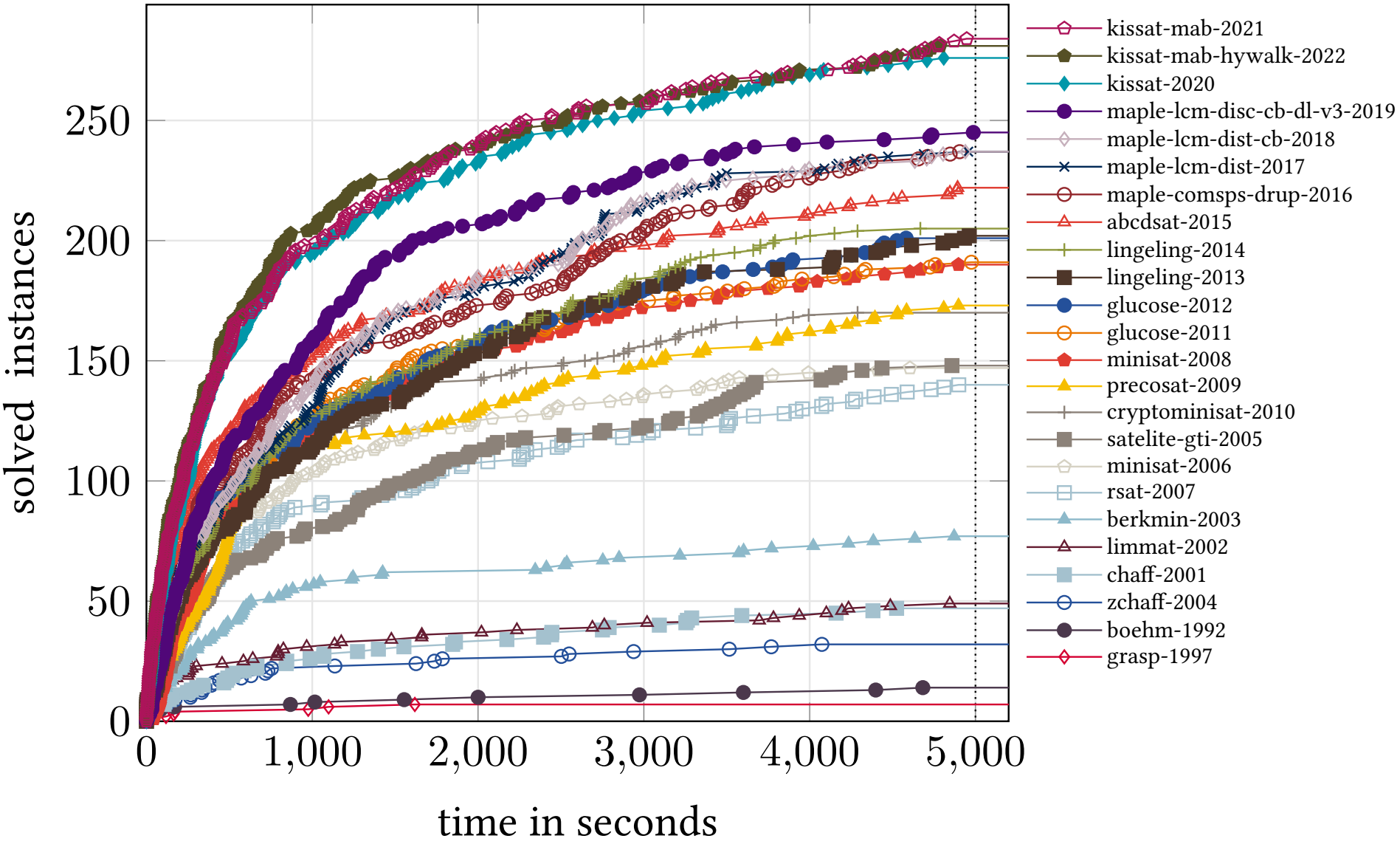
# Two Decades of SAT Competition Main / Application Benchmarks

- 100 benchmarks of first “modern” SAT competition 2002
- 300 benchmarks in 2011 competition
  - different organizers
  - CDCL improvements vs. inprocessing solvers
- 400 benchmarks in the SAT Race 2019 (when this work started)
- 400 benchmarks for each of the last three years in 2020 - 2022 as well as **2023**
  - satisfies the SAT practitioner’s manifesto
  - much more trusted results as proofs became mandatory
  - focus on submitted benchmarks: bring-your-own benchmarks
  - smaller batches (max. 14) of benchmarks from the same group
  - another decade later

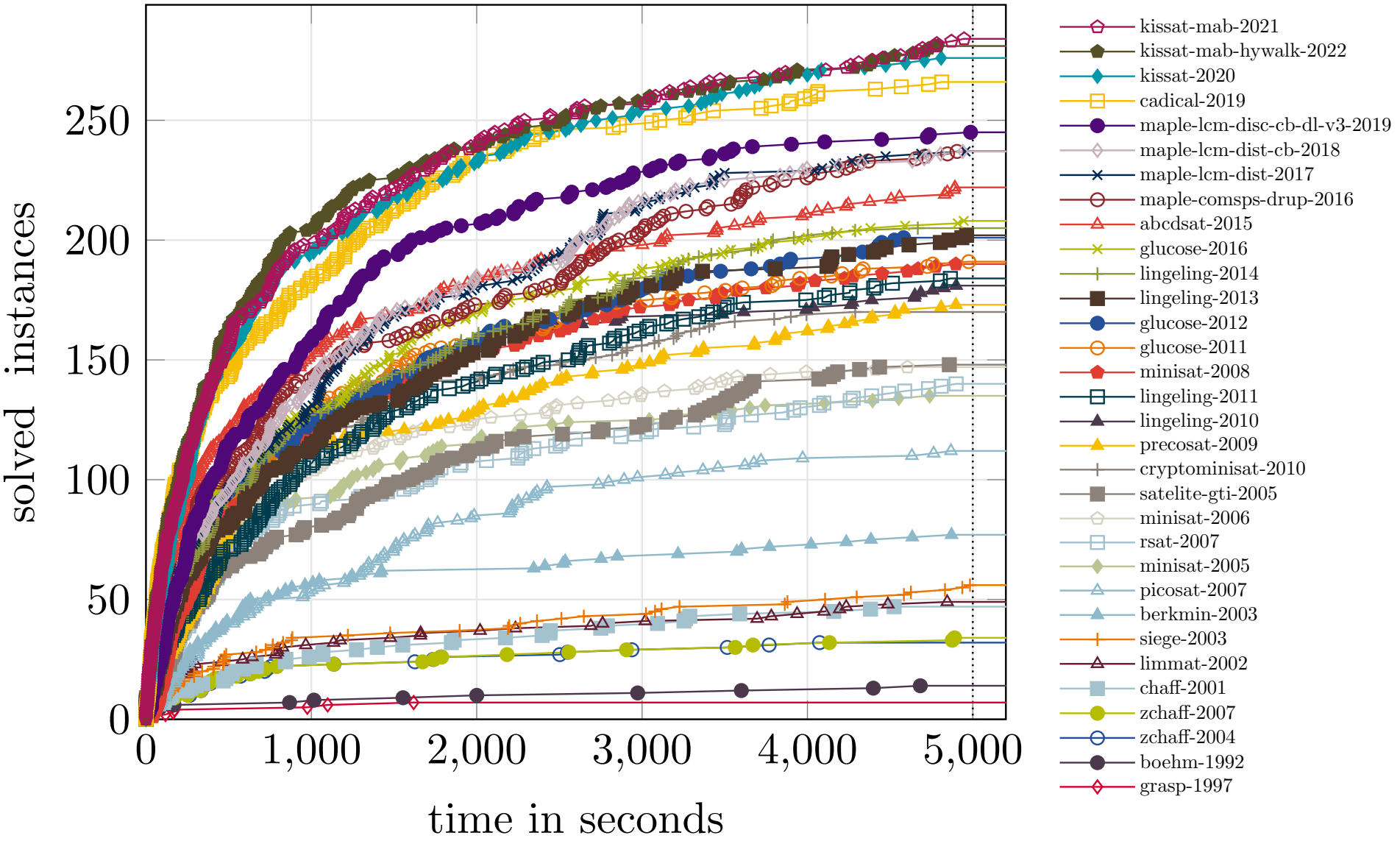
# Execution Environment

- Hardware
  - 32 node cluster with two processors per node
  - 8-core Intel Xeon E5-2620 v4 CPUs at 2.10 GHz (no turbo-mode)
  - memory limit 127 GB (increased iteratively)
  - time limit 500 seconds (as in recent SAT competitions)
- Software
  - Slurm: whenever possible maximum usage of (512) cores
  - Ubuntu 20.04
  - gcc 9.4.0 (64-bit)
  - runlim

# All-Time Winners — SAT Competition 2022 — Solved



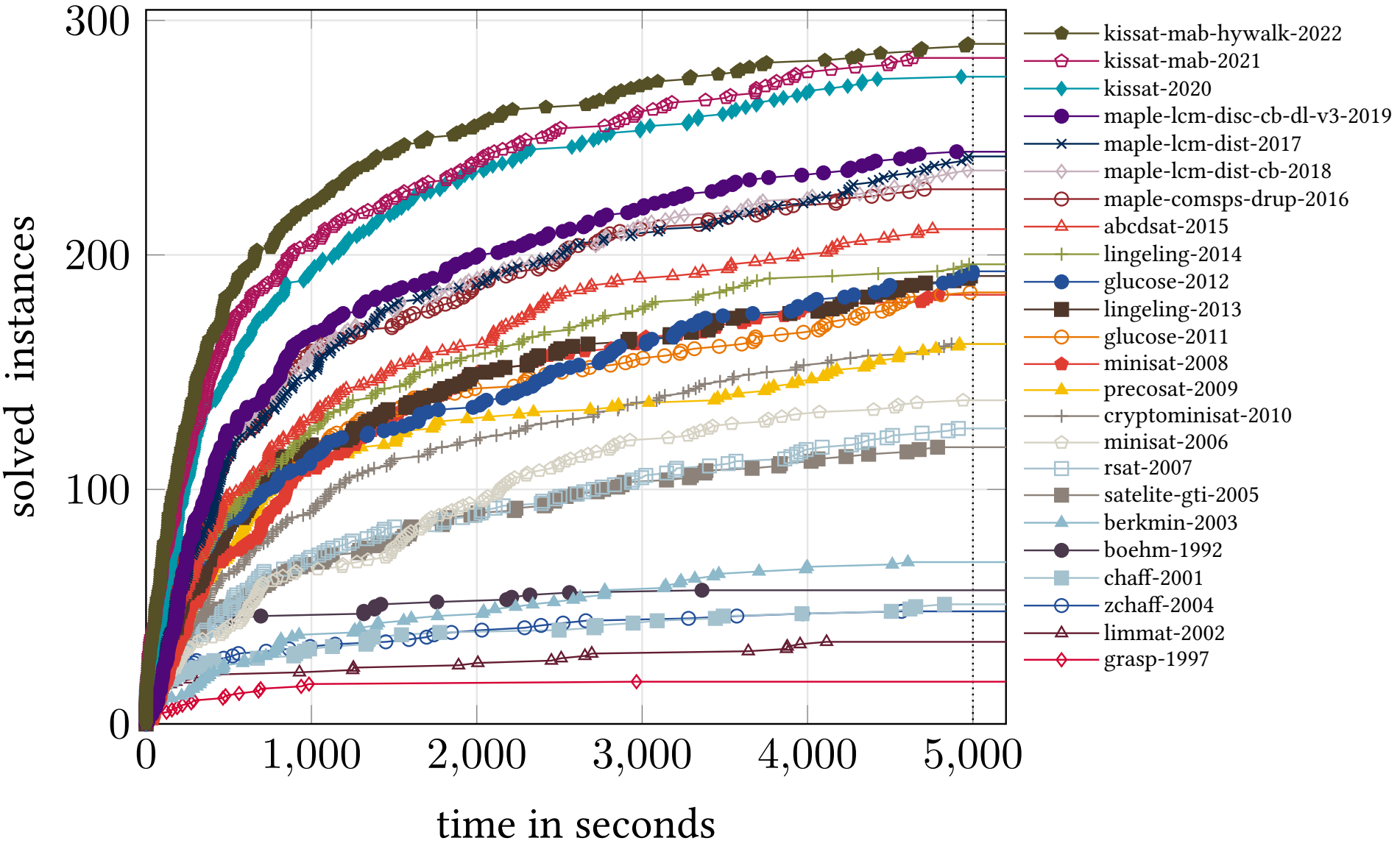
# Winners & Legacy Solvers — SAT Competition 2022 — Solved



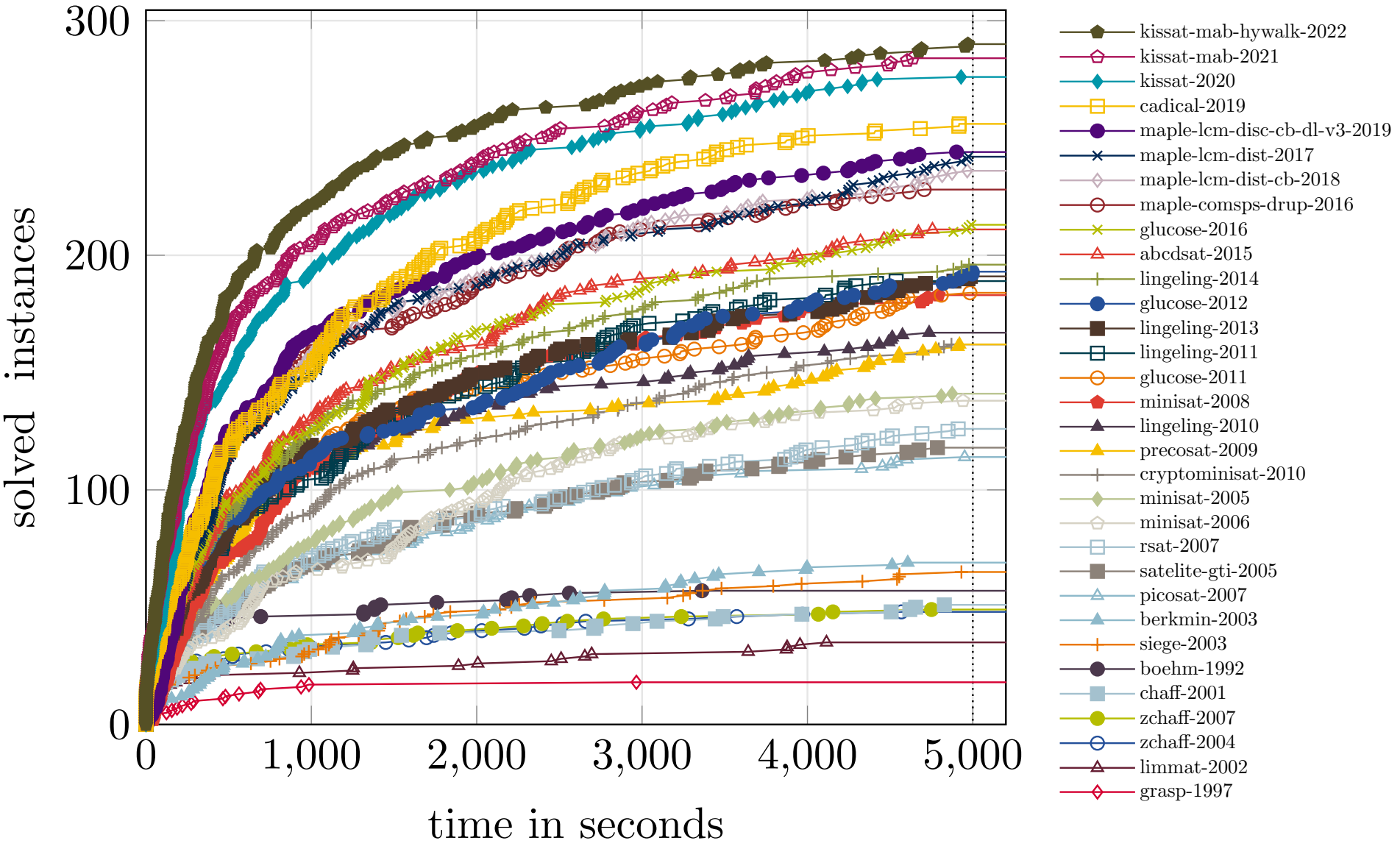
# Winners & Legacy Solvers — SAT Competition 2022

| solver | solved | sat | uns | fld | to | s11 | s6 | unk | time | space | max | best | uniq |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kissat-mab-2021 | 284 | 138 | 146 | 116 | 116 | 0 | 0 | 0 | 265782 | 150888 | 8560 | 26 | 1 |
| kissat-mab-hywalk-2022 | 281 | 141 | 140 | 119 | 119 | 0 | 0 | 0 | 243481 | 144848 | 5074 | 24 | 2 |
| kissat-2020 | 276 | 133 | 143 | 124 | 124 | 0 | 0 | 0 | 250172 | 140684 | 5800 | 35 | 3 |
| cadical-2019 | 266 | 130 | 136 | 134 | 134 | 0 | 0 | 0 | 226275 | 338834 | 15287 | 42 | 1 |
| maple-lcm-disc-cb-dl-v3-2019 | 245 | 114 | 131 | 155 | 155 | 0 | 0 | 0 | 240050 | 252515 | 15342 | 4 | 0 |
| maple-lcm-dist-cb-2018 | 237 | 107 | 130 | 163 | 163 | 0 | 0 | 0 | 278238 | 241274 | 15342 | 14 | 1 |
| maple-lcm-dist-2017 | 237 | 109 | 128 | 163 | 157 | 6 | 0 | 0 | 282569 | 232392 | 15342 | 12 | 0 |
| maple-comsps-drup-2016 | 237 | 109 | 128 | 163 | 163 | 0 | 0 | 0 | 296217 | 254699 | 13707 | 33 | 0 |
| abcdsat-2015 | 222 | 102 | 120 | 178 | 175 | 1 | 2 | 0 | 218955 | 160324 | 11921 | 27 | 7 |
| glucose-2016 | 208 | 93 | 115 | 192 | 192 | 0 | 0 | 0 | 220600 | 150531 | 11923 | 1 | 0 |
| lingeling-2014 | 205 | 98 | 107 | 195 | 195 | 0 | 0 | 0 | 229105 | 153486 | 6317 | 2 | 0 |
| lingeling-2013 | 202 | 86 | 116 | 198 | 198 | 0 | 0 | 0 | 249622 | 124551 | 6233 | 4 | 0 |
| glucose-2012 | 201 | 88 | 113 | 199 | 198 | 0 | 0 | 1 | 225987 | 112212 | 5424 | 8 | 0 |
| glucose-2011 | 191 | 85 | 106 | 209 | 209 | 0 | 0 | 0 | 189747 | 109528 | 7737 | 17 | 0 |
| minisat-2008 | 190 | 91 | 99 | 210 | 210 | 0 | 0 | 0 | 210046 | 194259 | 11139 | 12 | 0 |
| lingeling-2011 | 184 | 89 | 95 | 216 | 211 | 1 | 0 | 4 | 227743 | 92008 | 4111 | 5 | 0 |
| lingeling-2010 | 181 | 82 | 99 | 219 | 211 | 0 | 0 | 8 | 173349 | 98203 | 6965 | 3 | 0 |
| precosat-2009 | 173 | 85 | 88 | 227 | 226 | 0 | 0 | 1 | 211820 | 258453 | 21011 | 10 | 0 |
| cryptominisat-2010 | 170 | 74 | 96 | 230 | 194 | 0 | 0 | 36 | 158503 | 130699 | 6645 | 14 | 1 |
| satelite-gti-2005 | 148 | 72 | 76 | 252 | 252 | 0 | 0 | 0 | 191724 | 180730 | 18383 | 1 | 0 |
| minisat-2006 | 147 | 64 | 83 | 253 | 253 | 0 | 0 | 0 | 131637 | 100257 | 11749 | 4 | 0 |
| rsat-2007 | 140 | 69 | 71 | 260 | 247 | 0 | 0 | 13 | 170097 | 151735 | 18921 | 2 | 1 |
| minisat-2005 | 135 | 60 | 75 | 265 | 254 | 0 | 0 | 11 | 118366 | 110412 | 11838 | 6 | 0 |
| picosat-2007 | 112 | 57 | 55 | 288 | 273 | 0 | 0 | 15 | 146944 | 37585 | 3879 | 0 | 0 |
| berkmin-2003 | 77 | 36 | 41 | 323 | 304 | 0 | 0 | 19 | 77844 | 17913 | 4066 | 0 | 0 |
| siege-2003 | 56 | 42 | 14 | 344 | 242 | 0 | 0 | 102 | 82966 | 15819 | 3385 | 2 | 0 |
| limmat-2002 | 49 | 24 | 25 | 351 | 324 | 0 | 27 | 0 | 61160 | 119707 | 15146 | 7 | 0 |
| chaff-2001 | 47 | 26 | 21 | 353 | 353 | 0 | 0 | 0 | 63674 | 91987 | 20260 | 1 | 0 |
| zchaff-2007 | 34 | 24 | 10 | 366 | 281 | 0 | 0 | 85 | 41662 | 9359 | 995 | 3 | 0 |
| zchaff-2004 | 32 | 23 | 9 | 368 | 283 | 0 | 0 | 85 | 32304 | 7984 | 875 | 0 | 0 |
| boehm1-1992 | 14 | 11 | 3 | 386 | 381 | 5 | 0 | 0 | 21429 | 38911 | 35939 | 0 | 0 |
| grasp-1997 | 7 | 6 | 1 | 393 | 393 | 0 | 0 | 0 | 4156 | 90404 | 83832 | 1 | 0 |

# All-Time Winners — SAT Competition 2021



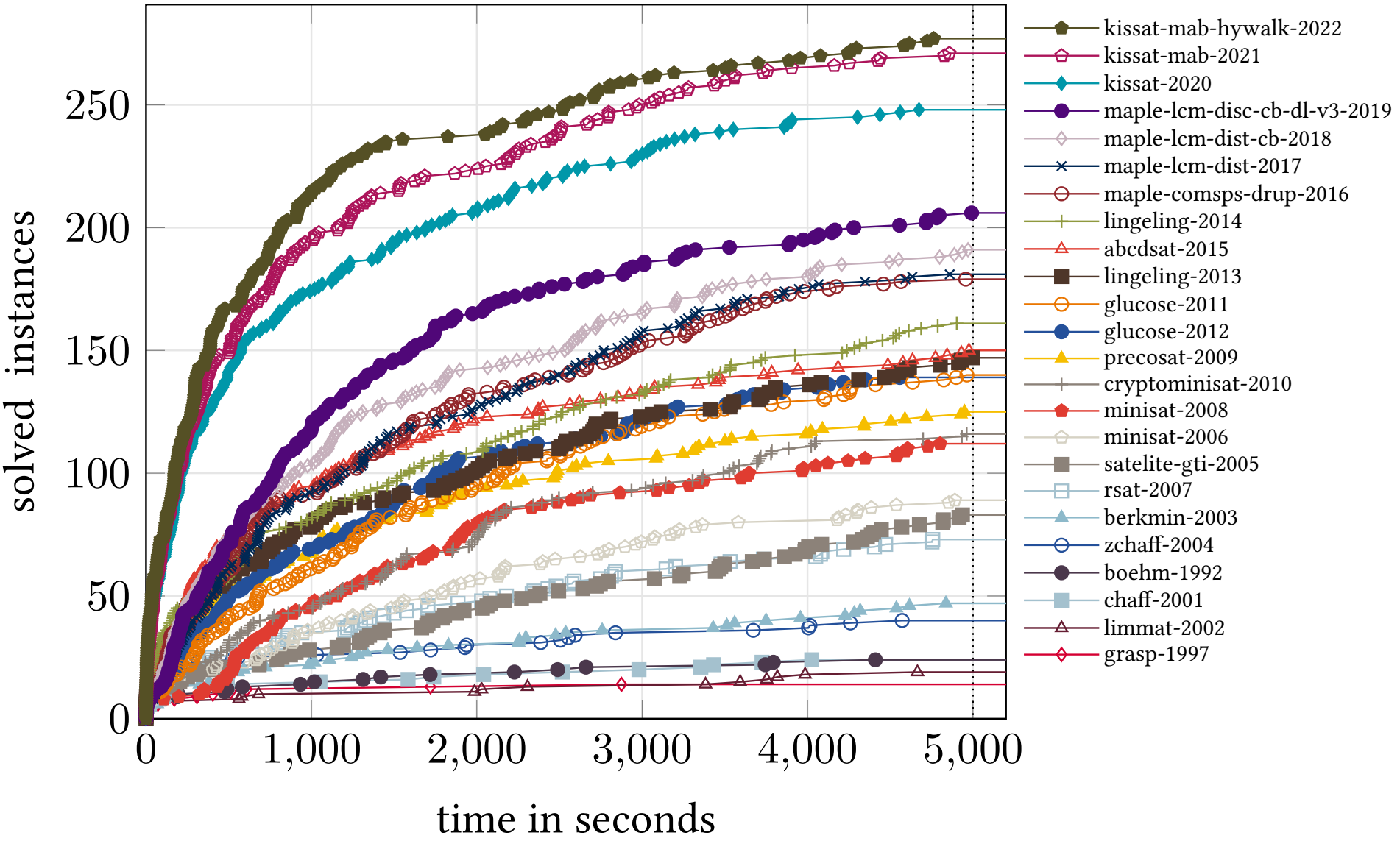
# Winners & Legacy Solvers — SAT Competition 2021



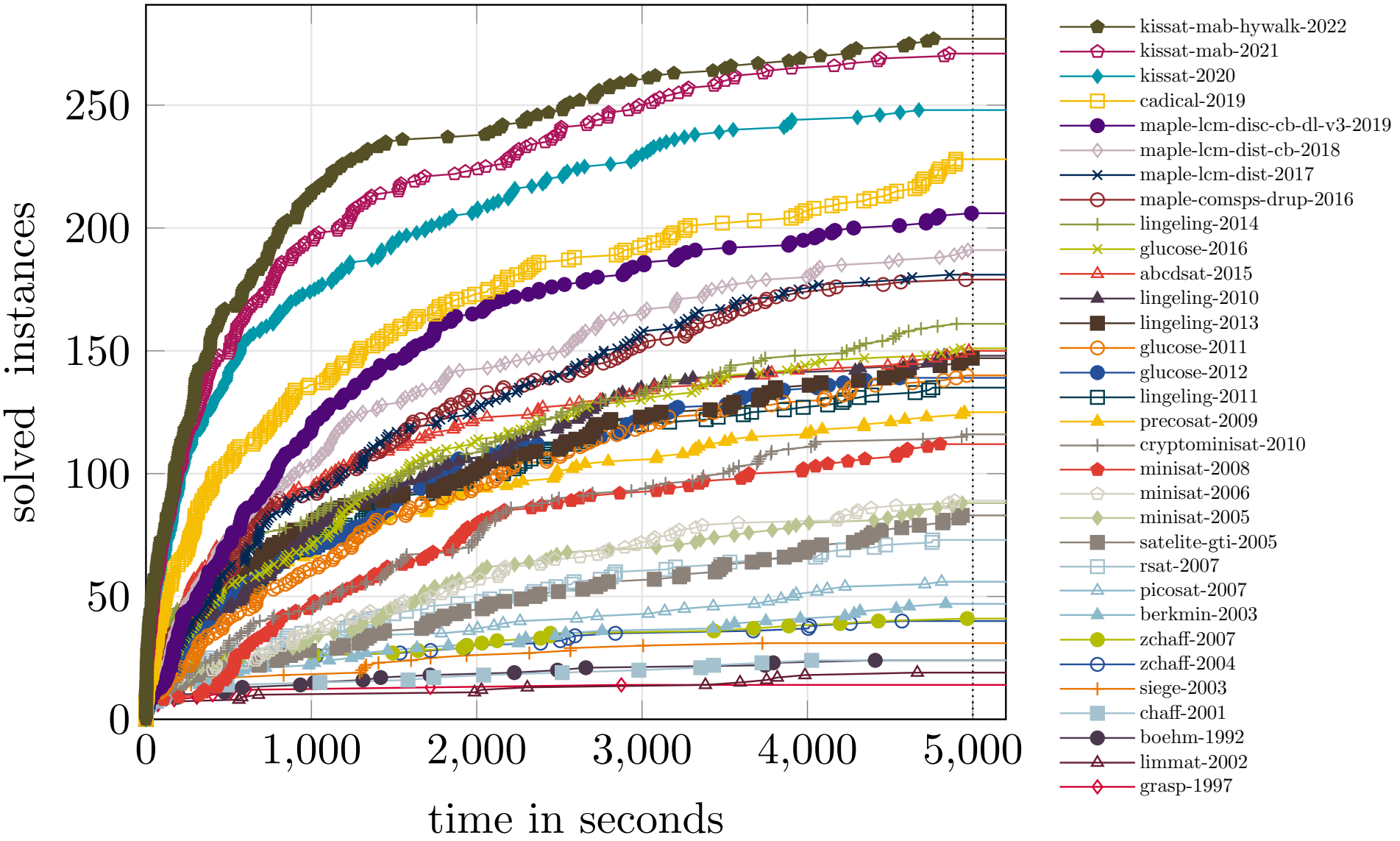
# Winners & Legacy Solvers — SAT Competition 2021

| solver | solved | sat | uns | fld | to | mo | s11 | s6 | unk | time | space | max | best | uniq |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kissat-mab-hywalk-2022 | 290 | 148 | 142 | 110 | 110 | 0 | 0 | 0 | 0 | 220938 | 67710 | 2362 | 35 | 4 |
| kissat-mab-2021 | 284 | 143 | 141 | 116 | 116 | 0 | 0 | 0 | 0 | 248861 | 67659 | 2405 | 24 | 0 |
| kissat-2020 | 276 | 127 | 149 | 124 | 124 | 0 | 0 | 0 | 0 | 249290 | 71045 | 2478 | 54 | 3 |
| cadical-2019 | 256 | 121 | 135 | 144 | 144 | 0 | 0 | 0 | 0 | 271434 | 153413 | 4331 | 17 | 1 |
| maple-lcm-disc-cb-dl-v3-2019 | 244 | 109 | 135 | 156 | 156 | 0 | 0 | 0 | 0 | 255184 | 95426 | 2842 | 9 | 1 |
| maple-lcm-dist-2017 | 242 | 104 | 138 | 158 | 158 | 0 | 0 | 0 | 0 | 291999 | 101497 | 3106 | 6 | 0 |
| maple-lcm-dist-cb-2018 | 236 | 103 | 133 | 164 | 164 | 0 | 0 | 0 | 0 | 254683 | 95630 | 2885 | 12 | 0 |
| maple-comsps-drup-2016 | 228 | 101 | 127 | 172 | 172 | 0 | 0 | 0 | 0 | 226324 | 84985 | 2644 | 24 | 0 |
| glucose-2016 | 213 | 91 | 122 | 187 | 187 | 0 | 0 | 0 | 0 | 259282 | 65250 | 2236 | 21 | 2 |
| abcdsat-2015 | 211 | 90 | 121 | 189 | 189 | 0 | 0 | 0 | 0 | 241145 | 76009 | 3206 | 13 | 2 |
| lingeling-2014 | 196 | 85 | 111 | 204 | 199 | 0 | 0 | 0 | 5 | 211676 | 62424 | 4557 | 12 | 0 |
| glucose-2012 | 193 | 87 | 106 | 207 | 207 | 0 | 0 | 0 | 0 | 254867 | 70702 | 16696 | 8 | 0 |
| lingeling-2013 | 191 | 75 | 116 | 209 | 204 | 0 | 0 | 0 | 5 | 233513 | 69223 | 4599 | 13 | 1 |
| lingeling-2011 | 189 | 71 | 118 | 211 | 206 | 0 | 0 | 0 | 5 | 224258 | 59429 | 1612 | 4 | 1 |
| glucose-2011 | 184 | 80 | 104 | 216 | 216 | 0 | 0 | 0 | 0 | 219112 | 52933 | 1991 | 9 | 0 |
| minisat-2008 | 184 | 86 | 98 | 216 | 216 | 0 | 0 | 0 | 0 | 220271 | 104674 | 4767 | 3 | 0 |
| lingeling-2010 | 167 | 75 | 92 | 233 | 225 | 0 | 0 | 0 | 8 | 177092 | 43102 | 1628 | 5 | 0 |
| precosat-2009 | 162 | 75 | 87 | 238 | 232 | 0 | 0 | 0 | 6 | 191373 | 78727 | 3872 | 12 | 0 |
| cryptominisat-2010 | 162 | 67 | 95 | 238 | 225 | 0 | 1 | 0 | 12 | 212116 | 86447 | 3965 | 0 | 0 |
| minisat-2005 | 141 | 56 | 85 | 259 | 259 | 0 | 0 | 0 | 0 | 178458 | 57438 | 2616 | 9 | 0 |
| minisat-2006 | 138 | 55 | 83 | 262 | 262 | 0 | 0 | 0 | 0 | 199748 | 45593 | 1903 | 4 | 0 |
| rsat-2007 | 126 | 64 | 62 | 274 | 262 | 0 | 0 | 0 | 12 | 174228 | 67631 | 2517 | 3 | 0 |
| satelite-gti-2005 | 118 | 51 | 67 | 282 | 282 | 0 | 0 | 0 | 0 | 146521 | 35336 | 2424 | 3 | 0 |
| picosat-2007 | 114 | 50 | 64 | 286 | 278 | 0 | 0 | 0 | 8 | 137483 | 20636 | 1401 | 0 | 0 |
| berkmin-2003 | 69 | 25 | 44 | 331 | 282 | 0 | 0 | 0 | 49 | 97356 | 6934 | 699 | 6 | 0 |
| siege-2003 | 65 | 23 | 42 | 335 | 304 | 0 | 0 | 0 | 31 | 89911 | 7395 | 662 | 4 | 0 |
| boehm1-1992 | 57 | 27 | 30 | 343 | 334 | 0 | 9 | 0 | 0 | 26316 | 7786 | 2391 | 13 | 3 |
| chaff-2001 | 51 | 22 | 29 | 349 | 349 | 0 | 0 | 0 | 0 | 60342 | 26297 | 3396 | 1 | 0 |
| zchaff-2007 | 49 | 20 | 29 | 351 | 303 | 0 | 0 | 0 | 48 | 43681 | 8821 | 1024 | 2 | 0 |
| zchaff-2004 | 48 | 20 | 28 | 352 | 304 | 0 | 0 | 0 | 48 | 42284 | 8316 | 1024 | 1 | 0 |
| limmat-2002 | 35 | 15 | 20 | 365 | 333 | 0 | 0 | 32 | 0 | 38441 | 30369 | 6439 | 1 | 0 |
| grasp-1997 | 18 | 7 | 11 | 382 | 380 | 2 | 0 | 0 | 0 | 9084 | 17288 | 5649 | 0 | 0 |

# All-Time Winners — SAT Competition 2020



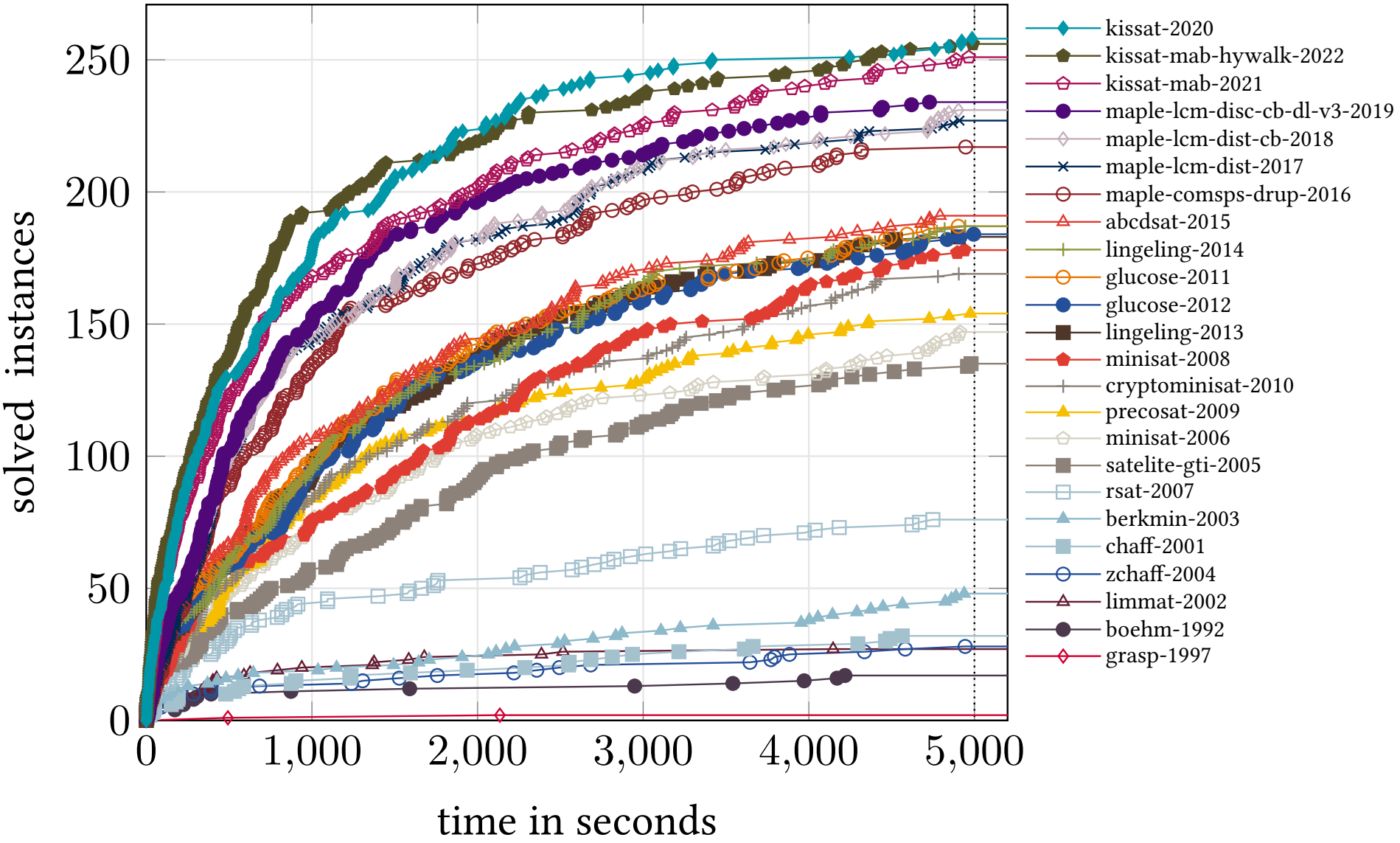
# Winners & Legacy Solvers — SAT Competition 2020



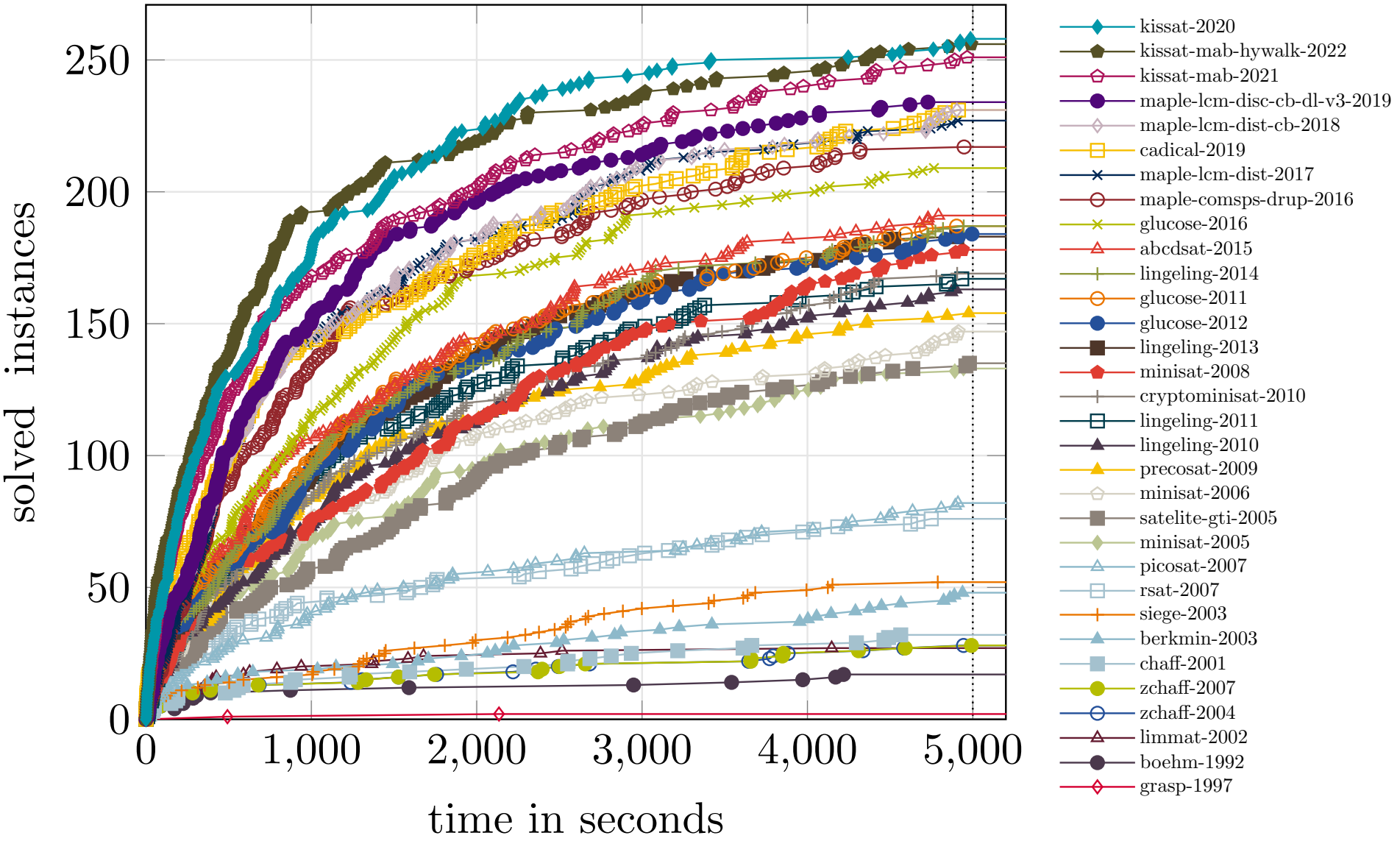
# Winners & Legacy Solvers — SAT Competition 2020

| solver | solved | sat | uns | fld | to | s11 | s6 | unk | time | space | max | best | uniq |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kissat-mab-hywalk-2022 | 277 | 158 | 119 | 123 | 123 | 0 | 0 | 0 | 214831 | 67973 | 4575 | 49 | 1 |
| kissat-mab-2021 | 271 | 153 | 118 | 129 | 129 | 0 | 0 | 0 | 237350 | 70471 | 4418 | 37 | 1 |
| kissat-2020 | 248 | 129 | 119 | 152 | 152 | 0 | 0 | 0 | 215423 | 67972 | 5114 | 57 | 3 |
| cadical-2019 | 228 | 121 | 107 | 172 | 172 | 0 | 0 | 0 | 289405 | 164622 | 15513 | 13 | 1 |
| maple-lcm-disc-cb-dl-v3-2019 | 206 | 101 | 105 | 194 | 194 | 0 | 0 | 0 | 250736 | 119009 | 6249 | 4 | 1 |
| maple-lcm-dist-cb-2018 | 191 | 87 | 104 | 209 | 209 | 0 | 0 | 0 | 248563 | 115347 | 7066 | 13 | 0 |
| maple-lcm-dist-2017 | 181 | 82 | 99 | 219 | 219 | 0 | 0 | 0 | 251961 | 111687 | 7709 | 12 | 0 |
| maple-comsps-drup-2016 | 179 | 80 | 99 | 221 | 221 | 0 | 0 | 0 | 242450 | 96267 | 7023 | 19 | 0 |
| lingeling-2014 | 162 | 77 | 85 | 238 | 237 | 0 | 0 | 1 | 236450 | 85629 | 5188 | 13 | 0 |
| glucose-2016 | 151 | 66 | 85 | 249 | 249 | 0 | 0 | 0 | 205369 | 82043 | 8771 | 13 | 0 |
| abcdsat-2015 | 150 | 62 | 88 | 250 | 248 | 0 | 2 | 0 | 165385 | 81932 | 8631 | 19 | 3 |
| lingeling-2010 | 148 | 79 | 69 | 252 | 251 | 0 | 0 | 1 | 196825 | 42995 | 3214 | 9 | 0 |
| lingeling-2013 | 147 | 69 | 78 | 253 | 250 | 0 | 0 | 3 | 209945 | 75364 | 5174 | 7 | 0 |
| glucose-2011 | 140 | 59 | 81 | 260 | 260 | 0 | 0 | 0 | 215104 | 72376 | 7509 | 6 | 0 |
| glucose-2012 | 139 | 58 | 81 | 261 | 261 | 0 | 0 | 0 | 184454 | 73041 | 7526 | 10 | 0 |
| lingeling-2011 | 135 | 56 | 79 | 265 | 264 | 0 | 0 | 1 | 178888 | 49053 | 3583 | 2 | 0 |
| precosat-2009 | 125 | 66 | 59 | 275 | 270 | 0 | 0 | 5 | 164445 | 107984 | 16941 | 13 | 1 |
| cryptominisat-2010 | 116 | 46 | 70 | 284 | 269 | 5 | 0 | 10 | 188457 | 54342 | 3970 | 5 | 0 |
| minisat-2008 | 112 | 55 | 57 | 288 | 286 | 0 | 0 | 2 | 184661 | 74288 | 5491 | 3 | 0 |
| minisat-2006 | 89 | 41 | 48 | 311 | 311 | 0 | 0 | 0 | 149848 | 32579 | 4964 | 3 | 0 |
| minisat-2005 | 88 | 37 | 51 | 312 | 312 | 0 | 0 | 0 | 150632 | 39746 | 4872 | 4 | 0 |
| satelite-gti-2005 | 83 | 37 | 46 | 317 | 317 | 0 | 0 | 0 | 171435 | 48682 | 4675 | 3 | 0 |
| rsat-2007 | 73 | 40 | 33 | 327 | 312 | 0 | 0 | 15 | 111743 | 52400 | 6758 | 2 | 0 |
| picosat-2007 | 56 | 29 | 27 | 344 | 329 | 0 | 0 | 15 | 86906 | 11861 | 1316 | 3 | 0 |
| berkmin-2003 | 47 | 26 | 21 | 353 | 305 | 0 | 0 | 48 | 76380 | 5508 | 2283 | 2 | 0 |
| zchaff-2007 | 41 | 20 | 21 | 359 | 322 | 0 | 0 | 37 | 46576 | 14483 | 1419 | 6 | 0 |
| zchaff-2004 | 40 | 20 | 20 | 360 | 323 | 0 | 0 | 37 | 44151 | 13978 | 1422 | 4 | 0 |
| siege-2003 | 31 | 16 | 15 | 369 | 315 | 0 | 0 | 54 | 29099 | 5862 | 2101 | 2 | 0 |
| chaff-2001 | 24 | 13 | 11 | 376 | 376 | 0 | 0 | 0 | 27685 | 12899 | 4139 | 4 | 0 |
| boehm1-1992 | 24 | 18 | 6 | 376 | 361 | 15 | 0 | 0 | 27802 | 2712 | 1784 | 2 | 0 |
| limmat-2002 | 19 | 8 | 11 | 381 | 346 | 0 | 35 | 0 | 31379 | 17802 | 8680 | 3 | 0 |
| grasp-1997 | 14 | 10 | 4 | 386 | 386 | 0 | 0 | 0 | 6758 | 14498 | 4218 | 3 | 0 |

# All-Time Winners — SAT Competition 2019



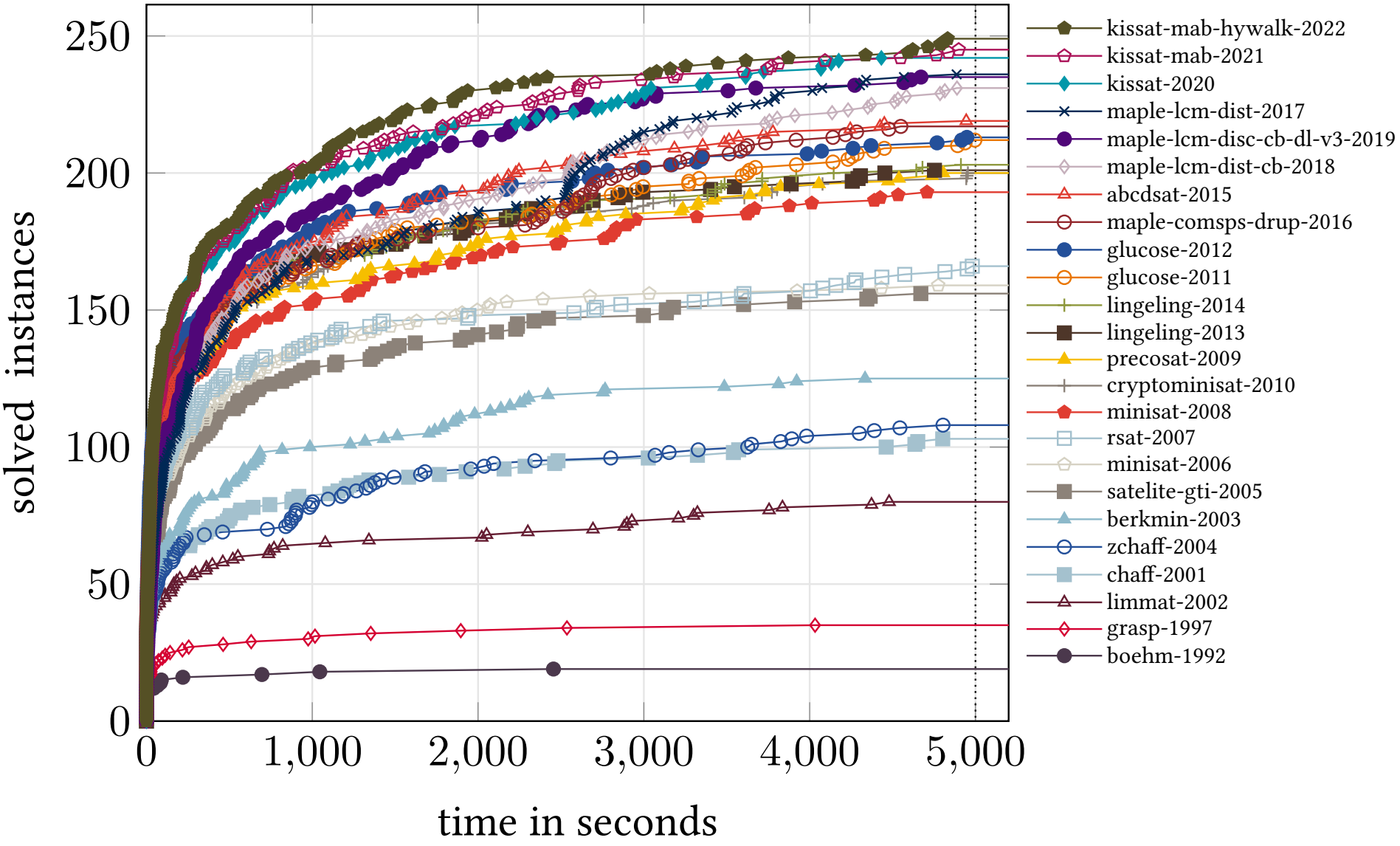
# Winners & Legacy Solvers — SAT Competition 2019



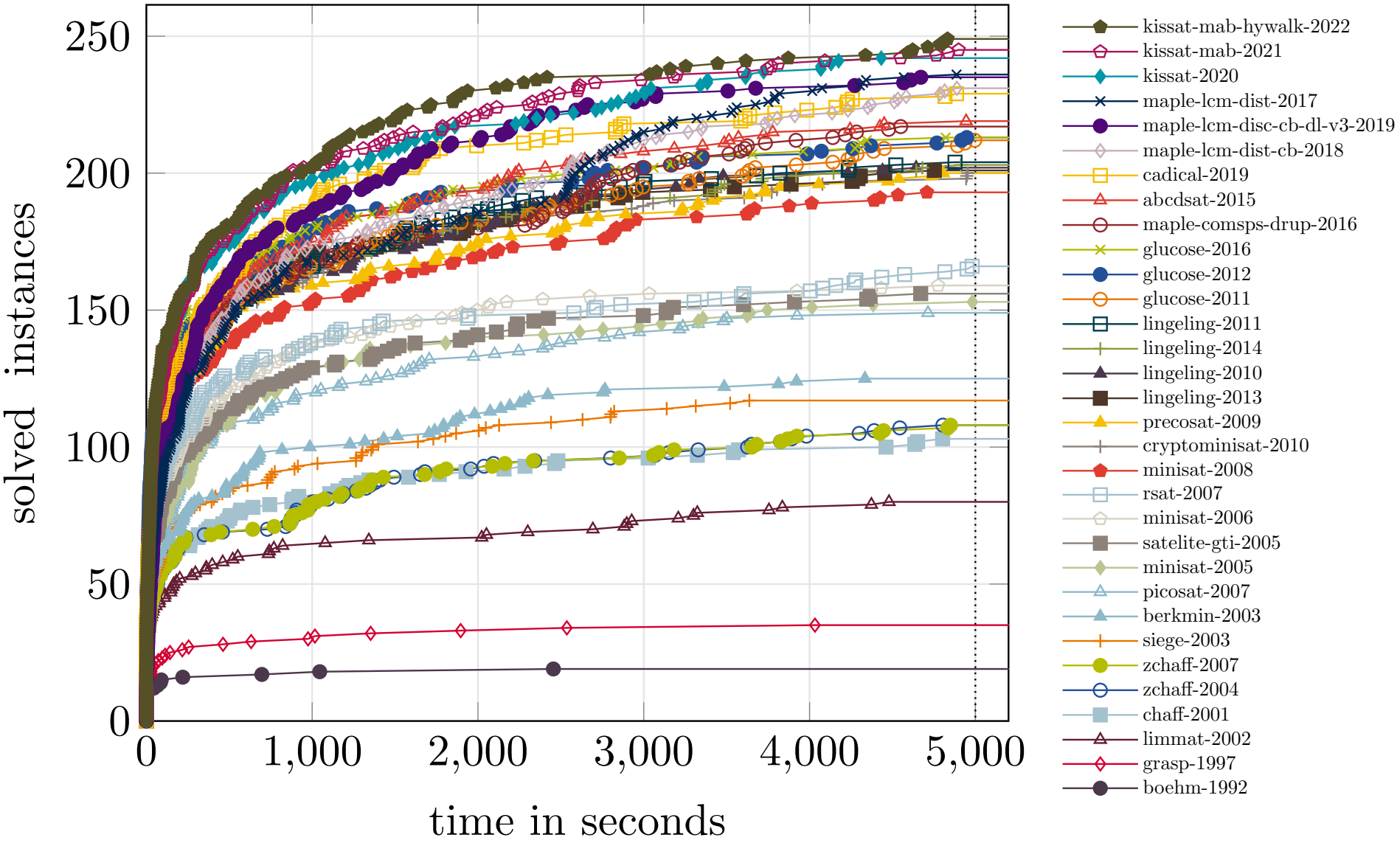
# Winners & Legacy Solvers — SAT Competition 2019

| solver | solved | sat | uns | fld | to | s11 | s6 | unk | time | space | max | best | uniq |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kissat-2020 | 258 | 158 | 100 | 142 | 142 | 0 | 0 | 0 | 231717 | 34028 | 4067 | 40 | 2 |
| kissat-mab-hywalk-2022 | 256 | 163 | 93 | 144 | 144 | 0 | 0 | 0 | 221039 | 31599 | 4128 | 29 | 1 |
| kissat-mab-2021 | 251 | 158 | 93 | 149 | 149 | 0 | 0 | 0 | 264842 | 33285 | 4233 | 18 | 0 |
| maple-lcm-disc-cb-dl-v3-2019 | 234 | 140 | 94 | 166 | 166 | 0 | 0 | 0 | 238701 | 82240 | 8922 | 16 | 0 |
| maple-lcm-dist-cb-2018 | 231 | 136 | 95 | 169 | 169 | 0 | 0 | 0 | 268028 | 74120 | 8923 | 12 | 0 |
| cadical-2019 | 231 | 141 | 90 | 169 | 169 | 0 | 0 | 0 | 277271 | 72814 | 8698 | 19 | 2 |
| maple-lcm-dist-2017 | 227 | 130 | 97 | 173 | 173 | 0 | 0 | 0 | 252583 | 78596 | 8923 | 17 | 1 |
| maple-comsps-drup-2016 | 217 | 125 | 92 | 183 | 183 | 0 | 0 | 0 | 244148 | 67470 | 8105 | 18 | 1 |
| glucose-2016 | 209 | 124 | 85 | 191 | 191 | 0 | 0 | 0 | 257139 | 58077 | 7135 | 5 | 0 |
| abcdsat-2015 | 191 | 111 | 80 | 209 | 207 | 1 | 1 | 0 | 240830 | 59965 | 7105 | 21 | 0 |
| glucose-2011 | 187 | 112 | 75 | 213 | 213 | 0 | 0 | 0 | 246218 | 49368 | 4130 | 7 | 0 |
| lingeling-2014 | 187 | 110 | 77 | 213 | 213 | 0 | 0 | 0 | 257272 | 41979 | 5251 | 13 | 1 |
| glucose-2012 | 184 | 108 | 76 | 216 | 216 | 0 | 0 | 0 | 257042 | 46254 | 4129 | 16 | 0 |
| lingeling-2013 | 183 | 113 | 70 | 217 | 217 | 0 | 0 | 0 | 239510 | 44934 | 5234 | 4 | 0 |
| minisat-2008 | 178 | 118 | 60 | 222 | 222 | 0 | 0 | 0 | 292642 | 74993 | 5748 | 10 | 0 |
| cryptominisat-2010 | 169 | 96 | 73 | 231 | 226 | 0 | 0 | 5 | 250363 | 43261 | 8154 | 7 | 0 |
| lingeling-2011 | 167 | 106 | 61 | 233 | 233 | 0 | 0 | 0 | 213277 | 40642 | 4349 | 4 | 0 |
| lingeling-2010 | 163 | 112 | 51 | 237 | 237 | 0 | 0 | 0 | 243999 | 30599 | 3997 | 2 | 0 |
| precosat-2009 | 154 | 101 | 53 | 246 | 246 | 0 | 0 | 0 | 207678 | 49620 | 11147 | 8 | 2 |
| minisat-2006 | 147 | 97 | 50 | 253 | 253 | 0 | 0 | 0 | 218457 | 38943 | 5965 | 7 | 0 |
| satelite-gti-2005 | 135 | 91 | 44 | 265 | 265 | 0 | 0 | 0 | 210868 | 50667 | 11602 | 3 | 0 |
| minisat-2005 | 133 | 89 | 44 | 267 | 267 | 0 | 0 | 0 | 190479 | 42921 | 6450 | 5 | 0 |
| picosat-2007 | 82 | 66 | 16 | 318 | 316 | 0 | 0 | 2 | 133212 | 12288 | 2532 | 4 | 0 |
| rsat-2007 | 76 | 60 | 16 | 324 | 319 | 0 | 0 | 5 | 105305 | 29981 | 9670 | 3 | 0 |
| siege-2003 | 52 | 40 | 12 | 348 | 314 | 0 | 0 | 34 | 92321 | 6932 | 664 | 0 | 0 |
| berkmin-2003 | 48 | 31 | 17 | 352 | 342 | 0 | 0 | 10 | 97606 | 8075 | 3276 | 0 | 0 |
| chaff-2001 | 32 | 30 | 2 | 368 | 368 | 0 | 0 | 0 | 54936 | 13421 | 1058 | 0 | 0 |
| zchaff-2004 | 28 | 19 | 9 | 372 | 353 | 0 | 0 | 19 | 46945 | 5731 | 567 | 3 | 0 |
| zchaff-2007 | 28 | 19 | 9 | 372 | 353 | 0 | 0 | 19 | 47120 | 5705 | 567 | 0 | 0 |
| limmat-2002 | 27 | 27 | 0 | 373 | 346 | 0 | 27 | 0 | 20974 | 26296 | 8064 | 3 | 0 |
| boehm1-1992 | 17 | 6 | 11 | 383 | 375 | 8 | 0 | 0 | 23149 | 212 | 162 | 2 | 0 |
| grasp-1997 | 2 | 2 | 0 | 398 | 398 | 0 | 0 | 0 | 2627 | 732 | 370 | 0 | 0 |

# All-Time Winners — SAT Competition 2011



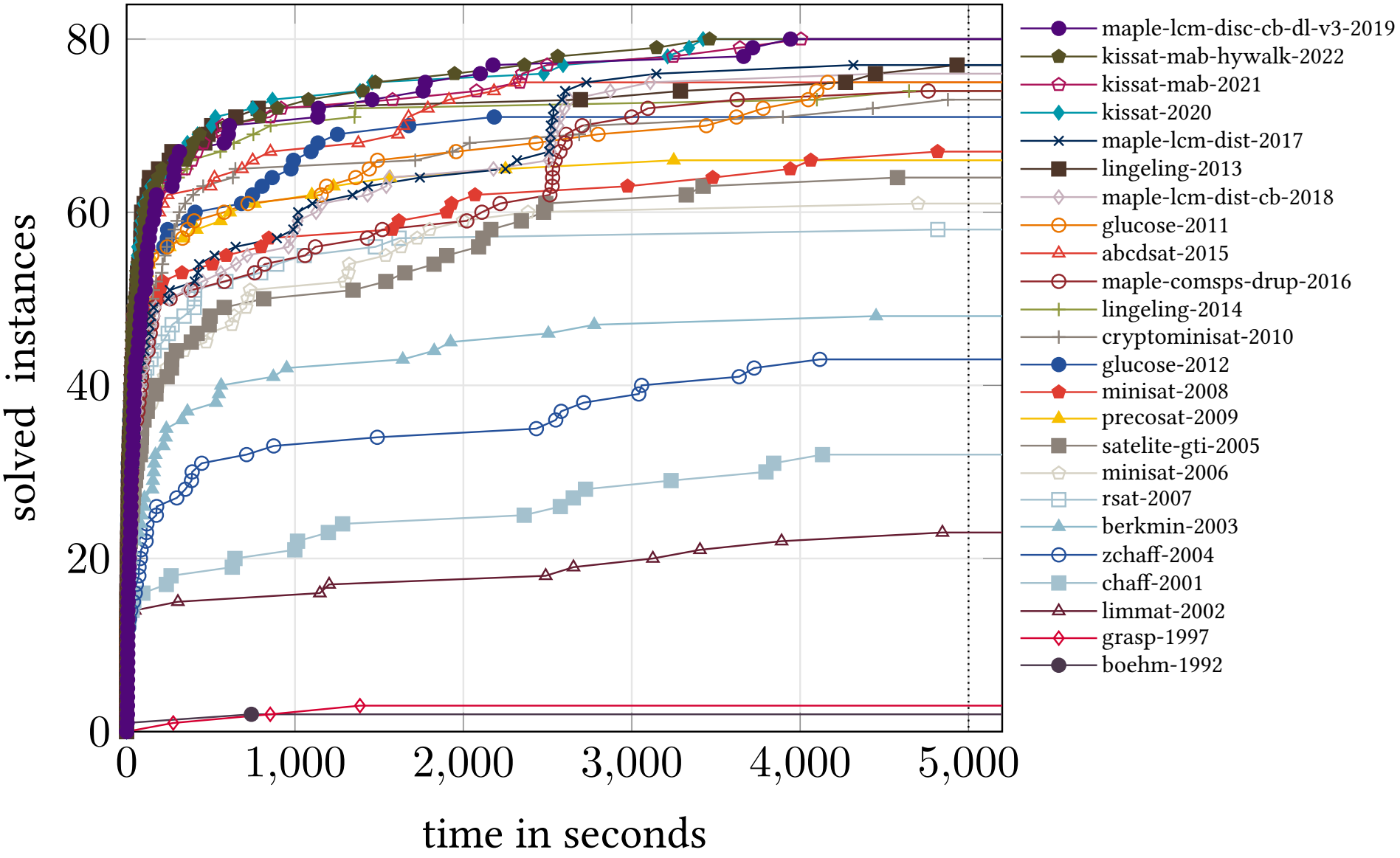
# Winners & Legacy Solvers — SAT Competition 2011



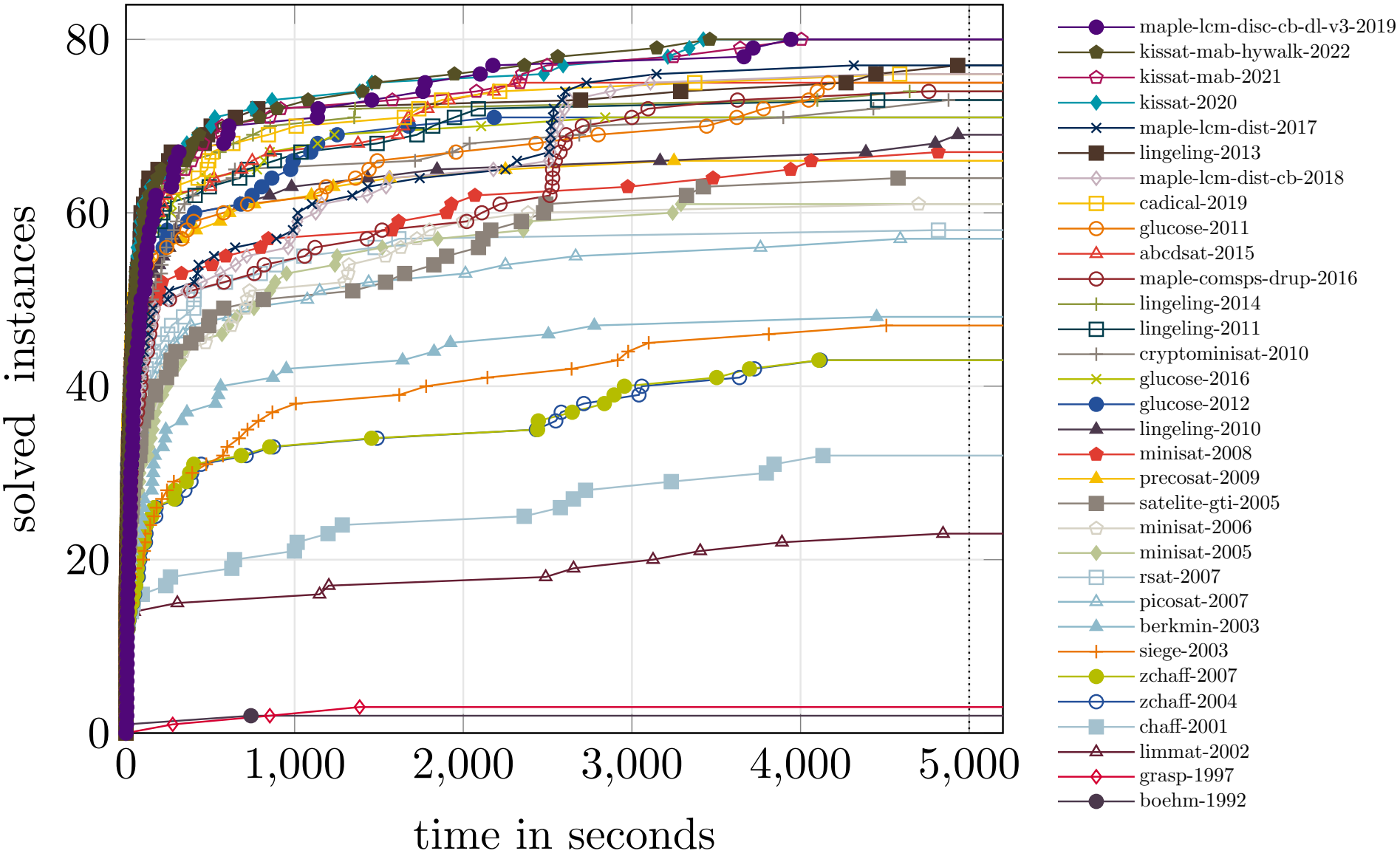
# Winners & Legacy Solvers — SAT Competition 2011

| solver | solved | sat | uns | fld | to | s11 | s6 | unk | time | space | max | best | uniq |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kissat-mab-hywalk-2022 | 249 | 110 | 139 | 51 | 51 | 0 | 0 | 0 | 136690 | 29157 | 1748 | 28 | 1 |
| kissat-mab-2021 | 245 | 108 | 137 | 55 | 55 | 0 | 0 | 0 | 137092 | 31230 | 1749 | 18 | 0 |
| kissat-2020 | 242 | 102 | 140 | 58 | 58 | 0 | 0 | 0 | 138677 | 30654 | 1723 | 37 | 0 |
| maple-lcm-dist-2017 | 236 | 101 | 135 | 64 | 64 | 0 | 0 | 0 | 217545 | 128294 | 14846 | 4 | 0 |
| maple-lcm-disc-cb-dl-v3-2019 | 235 | 102 | 133 | 65 | 65 | 0 | 0 | 0 | 142675 | 95658 | 5522 | 13 | 0 |
| maple-lcm-dist-cb-2018 | 231 | 99 | 132 | 69 | 69 | 0 | 0 | 0 | 192404 | 127379 | 12914 | 6 | 0 |
| cadical-2019 | 229 | 97 | 132 | 71 | 71 | 0 | 0 | 0 | 131644 | 70639 | 4817 | 22 | 0 |
| abcdsat-2015 | 219 | 92 | 127 | 81 | 79 | 0 | 2 | 0 | 131213 | 69415 | 4073 | 11 | 0 |
| maple-comsps-drup-2016 | 217 | 98 | 119 | 83 | 83 | 0 | 0 | 0 | 156551 | 57232 | 4958 | 9 | 0 |
| glucose-2016 | 213 | 93 | 120 | 87 | 87 | 0 | 0 | 0 | 109306 | 50482 | 4443 | 30 | 0 |
| glucose-2012 | 213 | 93 | 120 | 87 | 87 | 0 | 0 | 0 | 114492 | 48001 | 2832 | 22 | 0 |
| glucose-2011 | 212 | 93 | 119 | 88 | 88 | 0 | 0 | 0 | 148905 | 50432 | 2832 | 12 | 0 |
| lingeling-2011 | 204 | 90 | 114 | 96 | 96 | 0 | 0 | 0 | 109599 | 37195 | 2854 | 3 | 0 |
| lingeling-2014 | 203 | 91 | 112 | 97 | 97 | 0 | 0 | 0 | 113777 | 30264 | 2795 | 7 | 0 |
| lingeling-2010 | 202 | 98 | 104 | 98 | 98 | 0 | 0 | 0 | 112522 | 26464 | 2190 | 13 | 1 |
| lingeling-2013 | 201 | 94 | 107 | 99 | 99 | 0 | 0 | 0 | 105817 | 31462 | 2675 | 6 | 0 |
| cryptominisat-2010 | 200 | 85 | 115 | 100 | 97 | 0 | 0 | 3 | 115524 | 68605 | 5649 | 11 | 0 |
| precosat-2009 | 200 | 93 | 107 | 100 | 100 | 0 | 0 | 0 | 131686 | 89320 | 3451 | 8 | 0 |
| minisat-2008 | 193 | 94 | 99 | 107 | 107 | 0 | 0 | 0 | 120910 | 86809 | 10263 | 19 | 0 |
| rsat-2007 | 166 | 85 | 81 | 134 | 131 | 0 | 0 | 3 | 103143 | 68055 | 6931 | 1 | 0 |
| minisat-2006 | 159 | 83 | 76 | 141 | 141 | 0 | 0 | 0 | 69913 | 52669 | 7698 | 1 | 0 |
| satelite-gti-2005 | 156 | 76 | 80 | 144 | 144 | 0 | 0 | 0 | 86664 | 47973 | 2725 | 3 | 0 |
| minisat-2005 | 153 | 77 | 76 | 147 | 147 | 0 | 0 | 0 | 86498 | 52369 | 5116 | 11 | 0 |
| picosat-2007 | 149 | 77 | 72 | 151 | 151 | 0 | 0 | 0 | 87987 | 21297 | 1327 | 3 | 0 |
| berkmin-2003 | 125 | 58 | 67 | 175 | 169 | 0 | 0 | 6 | 73043 | 11192 | 559 | 8 | 0 |
| siege-2003 | 117 | 58 | 59 | 183 | 159 | 0 | 0 | 24 | 63728 | 12302 | 549 | 5 | 0 |
| zchaff-2004 | 108 | 51 | 57 | 192 | 174 | 0 | 0 | 18 | 86596 | 24272 | 1796 | 5 | 0 |
| zchaff-2007 | 108 | 51 | 57 | 192 | 175 | 0 | 0 | 17 | 86757 | 24408 | 1796 | 5 | 0 |
| chaff-2001 | 103 | 58 | 45 | 197 | 197 | 0 | 0 | 0 | 65514 | 42187 | 6074 | 6 | 0 |
| limmat-2002 | 80 | 46 | 34 | 220 | 162 | 0 | 58 | 0 | 54422 | 59747 | 5374 | 10 | 0 |
| grasp-1997 | 35 | 20 | 15 | 265 | 265 | 0 | 0 | 0 | 14049 | 17040 | 4787 | 3 | 0 |
| boehm1-1992 | 19 | 12 | 7 | 281 | 273 | 8 | 0 | 0 | 4708 | 1272 | 420 | 7 | 0 |

# All-Time Winners — SAT Competition 2002



# Winners & Legacy Solvers — SAT Competition 2002



# Winners & Legacy Solvers — SAT Competition 2002

| solver | solved | sat | uns | fld | to | s6 | unk | time | space | max | best |
|---|---|---|---|---|---|---|---|---|---|---|---|
| kissat-mab-hywalk-2022 | 80 | 23 | 57 | 20 | 20 | 0 | 0 | 23532 | 2322 | 274 | 3 |
| kissat-2020 | 80 | 23 | 57 | 20 | 20 | 0 | 0 | 24087 | 2301 | 239 | 17 |
| kissat-mab-2021 | 80 | 23 | 57 | 20 | 20 | 0 | 0 | 28537 | 2393 | 284 | 0 |
| maple-lcm-disc-cb-dl-v3-2019 | 80 | 23 | 57 | 20 | 20 | 0 | 0 | 29251 | 7021 | 388 | 2 |
| lingeling-2013 | 77 | 23 | 54 | 23 | 23 | 0 | 0 | 25243 | 3628 | 396 | 7 |
| maple-lcm-dist-2017 | 77 | 23 | 54 | 23 | 23 | 0 | 0 | 49480 | 6616 | 591 | 0 |
| cadical-2019 | 76 | 23 | 53 | 24 | 24 | 0 | 0 | 22059 | 5514 | 655 | 10 |
| maple-lcm-dist-cb-2018 | 76 | 23 | 53 | 24 | 24 | 0 | 0 | 49028 | 6123 | 388 | 0 |
| abcdsat-2015 | 75 | 23 | 52 | 25 | 25 | 0 | 0 | 20235 | 6637 | 721 | 9 |
| glucose-2011 | 75 | 23 | 52 | 25 | 25 | 0 | 0 | 41071 | 8788 | 1463 | 3 |
| lingeling-2014 | 74 | 23 | 51 | 26 | 26 | 0 | 0 | 17978 | 3163 | 322 | 1 |
| maple-comsps-drup-2016 | 74 | 23 | 51 | 26 | 26 | 0 | 0 | 53838 | 5841 | 533 | 3 |
| lingeling-2011 | 73 | 23 | 50 | 27 | 27 | 0 | 0 | 20054 | 3492 | 324 | 4 |
| cryptominisat-2010 | 73 | 23 | 50 | 27 | 27 | 0 | 0 | 31255 | 6569 | 686 | 1 |
| glucose-2016 | 71 | 23 | 48 | 29 | 29 | 0 | 0 | 13270 | 4868 | 530 | 9 |
| glucose-2012 | 71 | 23 | 48 | 29 | 29 | 0 | 0 | 15070 | 6237 | 785 | 8 |
| lingeling-2010 | 69 | 23 | 46 | 31 | 31 | 0 | 0 | 26986 | 2630 | 309 | 0 |
| minisat-2008 | 67 | 23 | 44 | 33 | 33 | 0 | 0 | 33261 | 8544 | 2990 | 2 |
| precosat-2009 | 66 | 23 | 43 | 34 | 34 | 0 | 0 | 14108 | 5550 | 723 | 3 |
| satelite-gti-2005 | 64 | 22 | 42 | 36 | 36 | 0 | 0 | 39026 | 6011 | 715 | 0 |
| minisat-2006 | 61 | 20 | 41 | 39 | 39 | 0 | 0 | 26616 | 6494 | 1149 | 0 |
| minisat-2005 | 61 | 21 | 40 | 39 | 39 | 0 | 0 | 27154 | 4318 | 771 | 1 |
| rsat-2007 | 58 | 22 | 36 | 42 | 42 | 0 | 0 | 15046 | 5191 | 524 | 0 |
| picosat-2007 | 57 | 23 | 34 | 43 | 43 | 0 | 0 | 23530 | 1961 | 424 | 1 |
| berkmin-2003 | 48 | 18 | 30 | 52 | 48 | 0 | 4 | 21435 | 1008 | 79 | 0 |
| siege-2003 | 47 | 16 | 31 | 53 | 49 | 0 | 4 | 33458 | 3345 | 249 | 0 |
| zchaff-2007 | 43 | 14 | 29 | 57 | 57 | 0 | 0 | 33368 | 3959 | 384 | 1 |
| zchaff-2004 | 43 | 14 | 29 | 57 | 57 | 0 | 0 | 34035 | 3919 | 383 | 0 |
| chaff-2001 | 32 | 13 | 19 | 68 | 0 | 0 | 68 | 31783 | 6727 | 930 | 0 |
| limmat-2002 | 23 | 12 | 11 | 77 | 70 | 7 | 0 | 23137 | 10536 | 3450 | 0 |
| grasp-1997 | 3 | 2 | 1 | 97 | 97 | 0 | 0 | 2516 | 1722 | 998 | 0 |
| boehm1-1992 | 2 | 0 | 2 | 98 | 98 | 0 | 0 | 742 | 4 | 2 | 0 |

# 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)

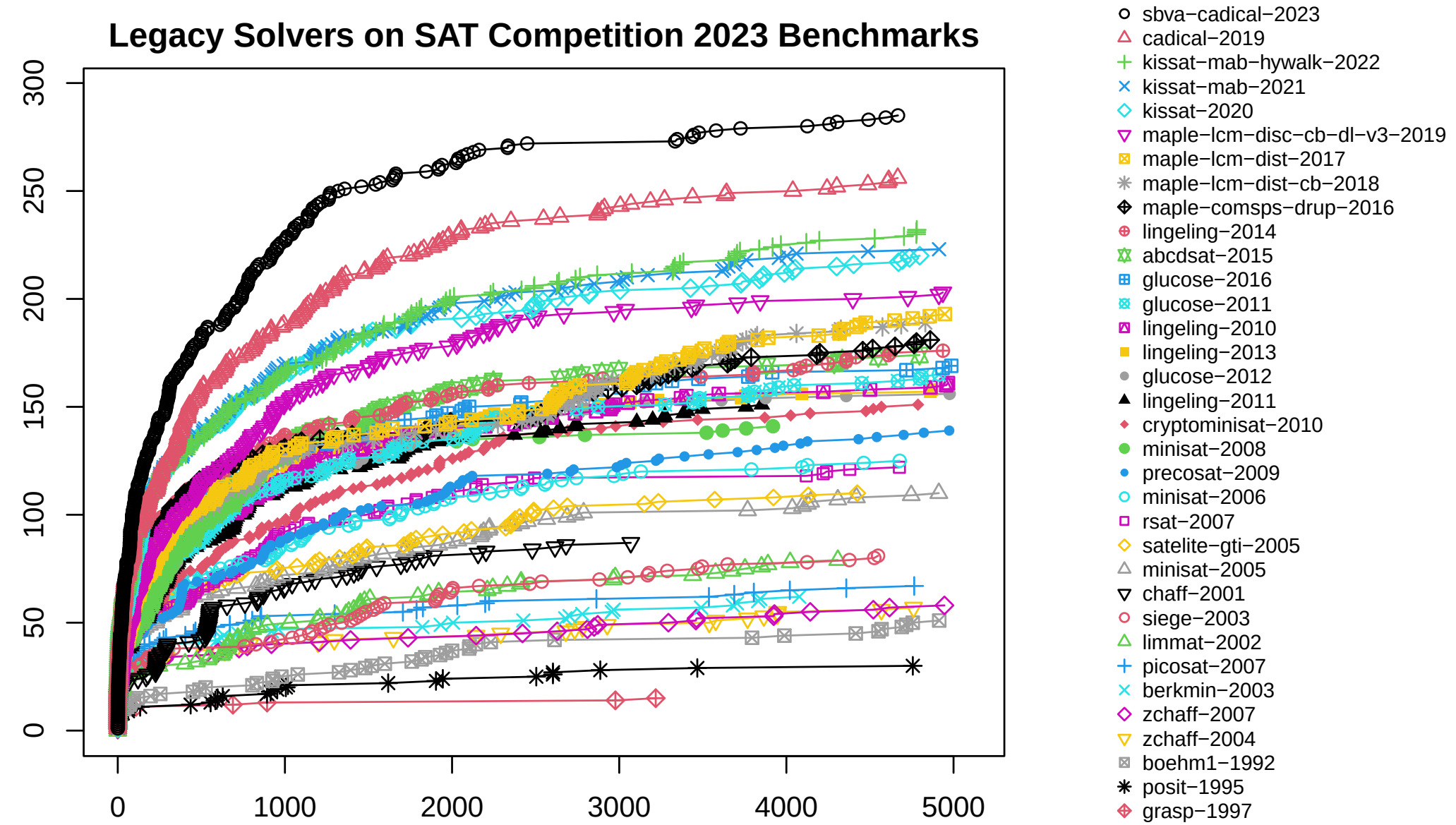
July 7, 2023

# What happened in 2023 after POS'23?

- SAT competition 2023 with surprising results

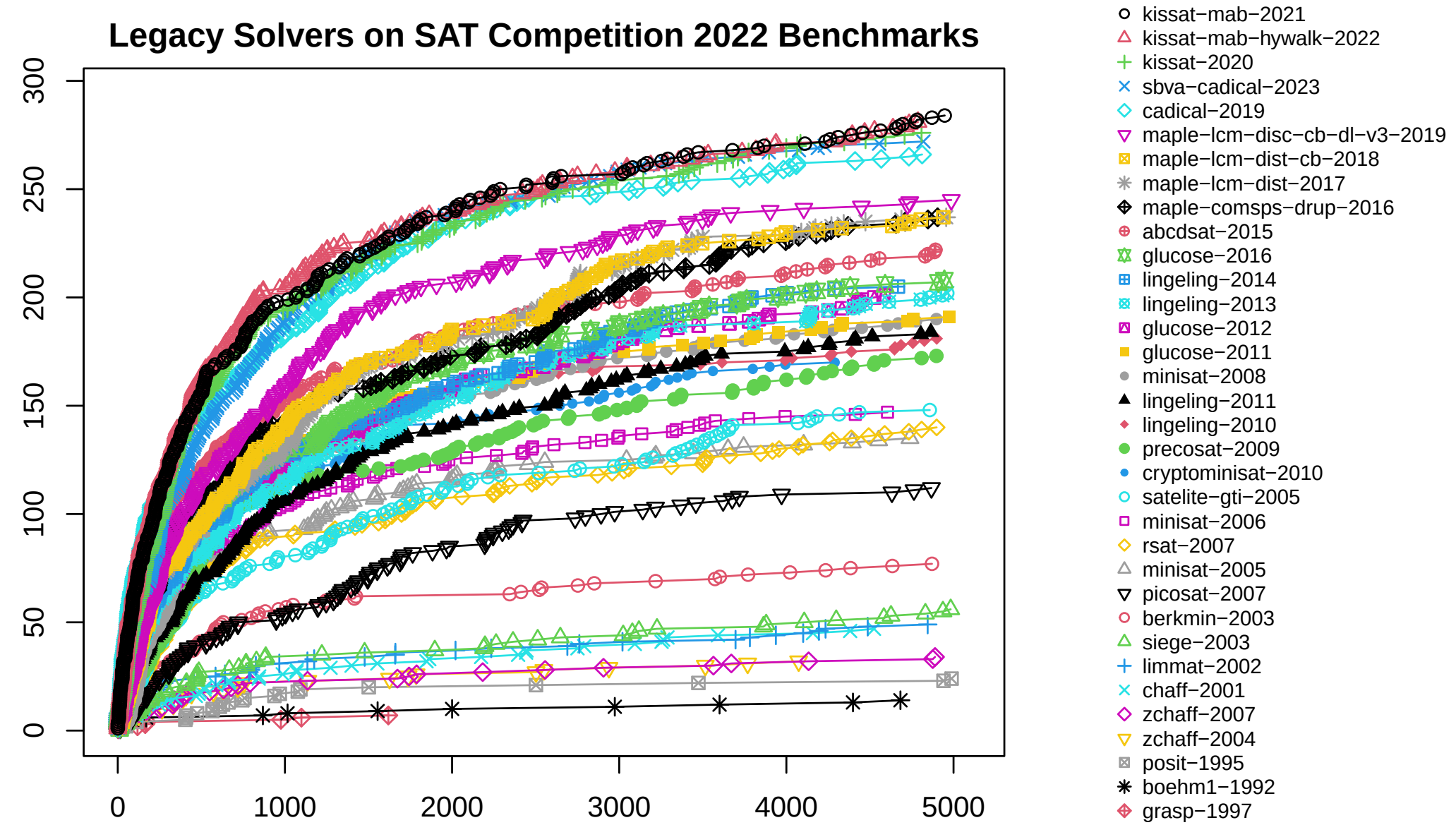
  "CaDiCaL strikes back"

- tight race for the top with several solvers with "symmetry reasoning"
  - first of all efficiently and effectively, but also with proofs
- (but) new implementation of bounded variable elimination (BVA) won
  [HaberlandtGreenHeule-SAT'23] better tie breaking than [MantheyHeuleBiere-HVC'11]
- teams arguably handed in benchmarks which benefit from these techniques
  - hard combinatorial benchmarks such as hash collision, pigeon holes, etc.
- do we see a large bias due to "bring your own benchmarks"?
  and many teams betting on the same kind of benchmarks


Legacy Solvers on SAT Competition 2023 Benchmarks
0
50
100
150
200
250
300
0
1000
2000
3000
4000
5000
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−comsps−drup−2016
lingeling−2014
abcdsat−2015
glucose−2016
glucose−2011
lingeling−2010
lingeling−2013
glucose−2012
lingeling−2011
cryptominisat−2010
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
boehm1−1992
posit−1995
grasp−1997

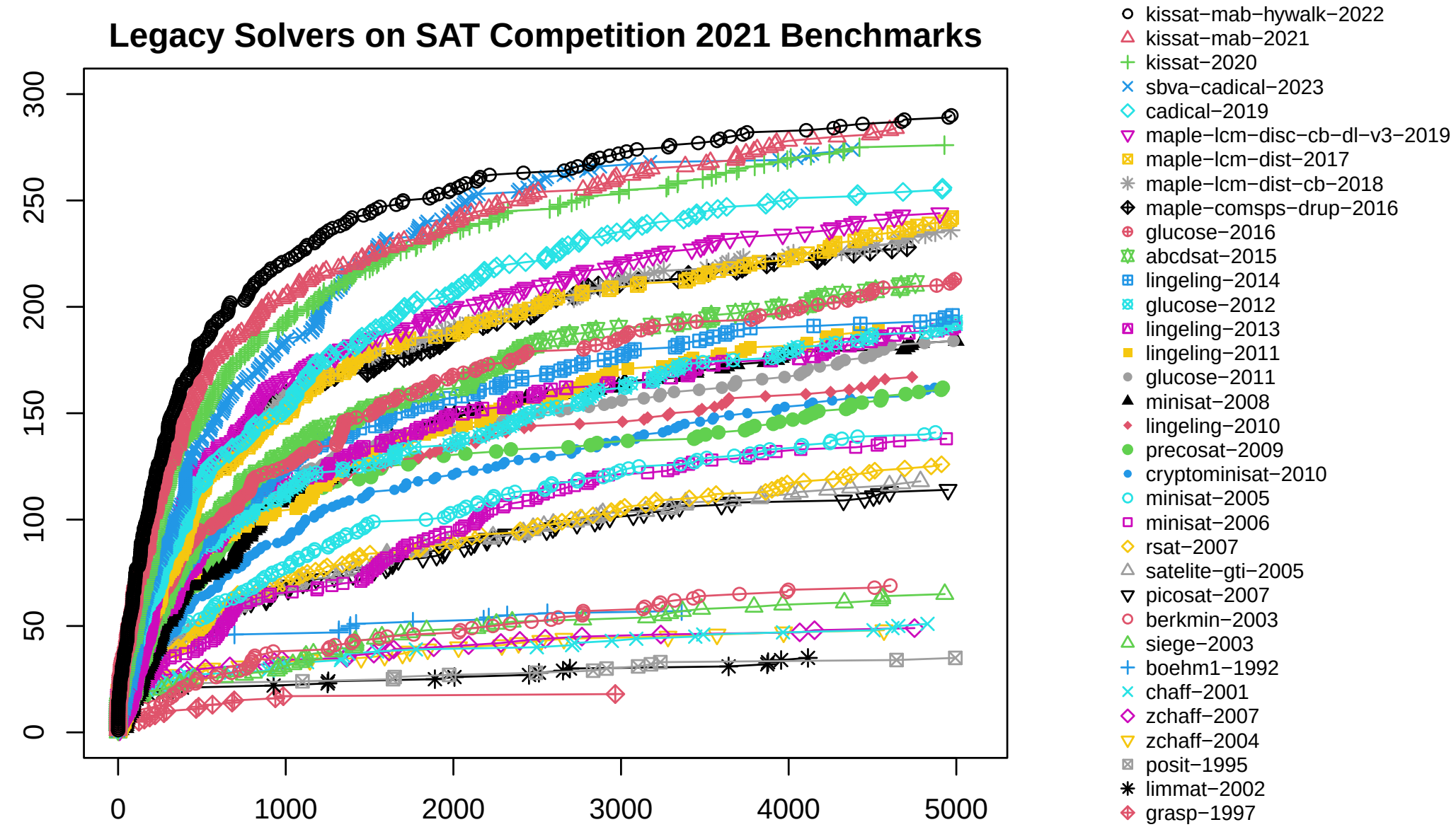
# Legacy Solvers — SAT Competition 2023

| solver | solved | sat | uns | fld | to | s11 | s6 | unk | time | space | max | best | uniq |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| sbva-cadical-2023 | 285 | 123 | 162 | 115 | 115 | 0 | 0 | 0 | 176968 | 656226 | 25424 | 40 | 10 |
| cadical-2019 | 256 | 117 | 139 | 144 | 144 | 0 | 0 | 0 | 189859 | 265132 | 17856 | 35 | 0 |
| kissat-mab-hywalk-2022 | 232 | 106 | 126 | 168 | 168 | 0 | 0 | 0 | 197690 | 103423 | 7886 | 16 | 1 |
| kissat-mab-2021 | 223 | 101 | 122 | 177 | 177 | 0 | 0 | 0 | 164198 | 101178 | 7886 | 15 | 0 |
| kissat-2020 | 220 | 97 | 123 | 180 | 180 | 0 | 0 | 0 | 171279 | 100824 | 7738 | 18 | 1 |
| maple-lcm-disc-cb-dl-v3-2019 | 203 | 75 | 128 | 197 | 197 | 0 | 0 | 0 | 156011 | 175959 | 12430 | 10 | 0 |
| maple-lcm-dist-2017 | 193 | 69 | 124 | 207 | 207 | 0 | 0 | 0 | 219246 | 169869 | 12431 | 6 | 0 |
| maple-lcm-dist-cb-2018 | 189 | 65 | 124 | 211 | 211 | 0 | 0 | 0 | 207834 | 172320 | 12430 | 4 | 0 |
| maple-comsps-drup-2016 | 181 | 70 | 111 | 219 | 219 | 0 | 0 | 0 | 170938 | 151271 | 11211 | 29 | 0 |
| lingeling-2014 | 176 | 60 | 116 | 224 | 224 | 0 | 0 | 0 | 130314 | 125554 | 10584 | 21 | 0 |
| abcdsat-2015 | 174 | 74 | 100 | 226 | 224 | 1 | 1 | 0 | 133485 | 139216 | 9693 | 8 | 0 |
| glucose-2016 | 169 | 68 | 101 | 231 | 231 | 0 | 0 | 0 | 126291 | 136950 | 10394 | 10 | 0 |
| glucose-2011 | 165 | 68 | 97 | 235 | 235 | 0 | 0 | 0 | 153415 | 114781 | 8026 | 13 | 0 |
| lingeling-2010 | 161 | 65 | 96 | 239 | 238 | 0 | 0 | 1 | 132551 | 96454 | 7630 | 14 | 0 |
| lingeling-2013 | 158 | 59 | 99 | 242 | 242 | 0 | 0 | 0 | 105440 | 123244 | 10427 | 16 | 0 |
| glucose-2012 | 156 | 63 | 93 | 244 | 244 | 0 | 0 | 0 | 115053 | 113506 | 8390 | 9 | 0 |
| lingeling-2011 | 151 | 68 | 83 | 249 | 247 | 0 | 0 | 2 | 114131 | 102526 | 8042 | 4 | 1 |
| cryptominisat-2010 | 151 | 53 | 98 | 249 | 223 | 0 | 0 | 26 | 141385 | 72967 | 7223 | 13 | 4 |
| minisat-2008 | 141 | 61 | 80 | 259 | 257 | 0 | 0 | 2 | 62599 | 130291 | 9176 | 22 | 0 |
| precosat-2009 | 139 | 51 | 88 | 261 | 261 | 0 | 0 | 0 | 149497 | 209108 | 17548 | 6 | 0 |
| minisat-2006 | 125 | 54 | 71 | 275 | 275 | 0 | 0 | 0 | 102875 | 93834 | 7192 | 11 | 0 |
| rsat-2007 | 122 | 55 | 67 | 278 | 269 | 0 | 0 | 9 | 91581 | 128617 | 10885 | 4 | 0 |
| satelite-gti-2005 | 110 | 48 | 62 | 290 | 290 | 0 | 0 | 0 | 89574 | 174206 | 14973 | 5 | 0 |
| minisat-2005 | 110 | 49 | 61 | 290 | 290 | 0 | 0 | 0 | 107882 | 24629 | 3534 | 10 | 0 |
| chaff-2001 | 87 | 41 | 46 | 313 | 313 | 0 | 0 | 0 | 57957 | 47125 | 5492 | 4 | 0 |
| siege-2003 | 81 | 32 | 49 | 319 | 257 | 0 | 0 | 62 | 93295 | 6289 | 282 | 9 | 0 |
| limmat-2002 | 79 | 41 | 38 | 321 | 295 | 1 | 25 | 0 | 83615 | 22088 | 2279 | 7 | 0 |
| picosat-2007 | 67 | 35 | 32 | 333 | 315 | 0 | 0 | 18 | 48671 | 6551 | 983 | 0 | 0 |
| berkmin-2003 | 62 | 26 | 36 | 338 | 301 | 0 | 0 | 37 | 52358 | 3553 | 801 | 3 | 0 |
| zchaff-2007 | 58 | 31 | 27 | 342 | 303 | 0 | 0 | 39 | 62240 | 5659 | 493 | 1 | 0 |
| zchaff-2004 | 57 | 30 | 27 | 343 | 304 | 0 | 0 | 39 | 57320 | 5446 | 493 | 0 | 0 |
| boehm1-1992 | 51 | 17 | 34 | 349 | 346 | 3 | 0 | 0 | 78139 | 2381 | 202 | 3 | 1 |
| posit-1995 | 30 | 14 | 16 | 370 | 266 | 0 | 0 | 104 | 32163 | 305 | 40 | 0 | 0 |
| grasp-1997 | 15 | 13 | 2 | 385 | 385 | 0 | 0 | 0 | 7935 | 2059 | 537 | 1 | 0 |


Legacy Solvers on SAT Competition 2022 Benchmarks
0
50
100
150
200
250
300
0
1000
2000
3000
4000
5000
kissat−mab−2021
kissat−mab−hywalk−2022
kissat−2020
sbva−cadical−2023
cadical−2019
maple−lcm−disc−cb−dl−v3−2019
maple−lcm−dist−cb−2018
maple−lcm−dist−2017
maple−comsps−drup−2016
abcdsat−2015
glucose−2016
lingeling−2014
lingeling−2013
glucose−2012
glucose−2011
minisat−2008
lingeling−2011
lingeling−2010
precosat−2009
cryptominisat−2010
satelite−gti−2005
minisat−2006
rsat−2007
minisat−2005
picosat−2007
berkmin−2003
siege−2003
limmat−2002
chaff−2001
zchaff−2007
zchaff−2004
posit−1995
boehm1−1992
grasp−1997

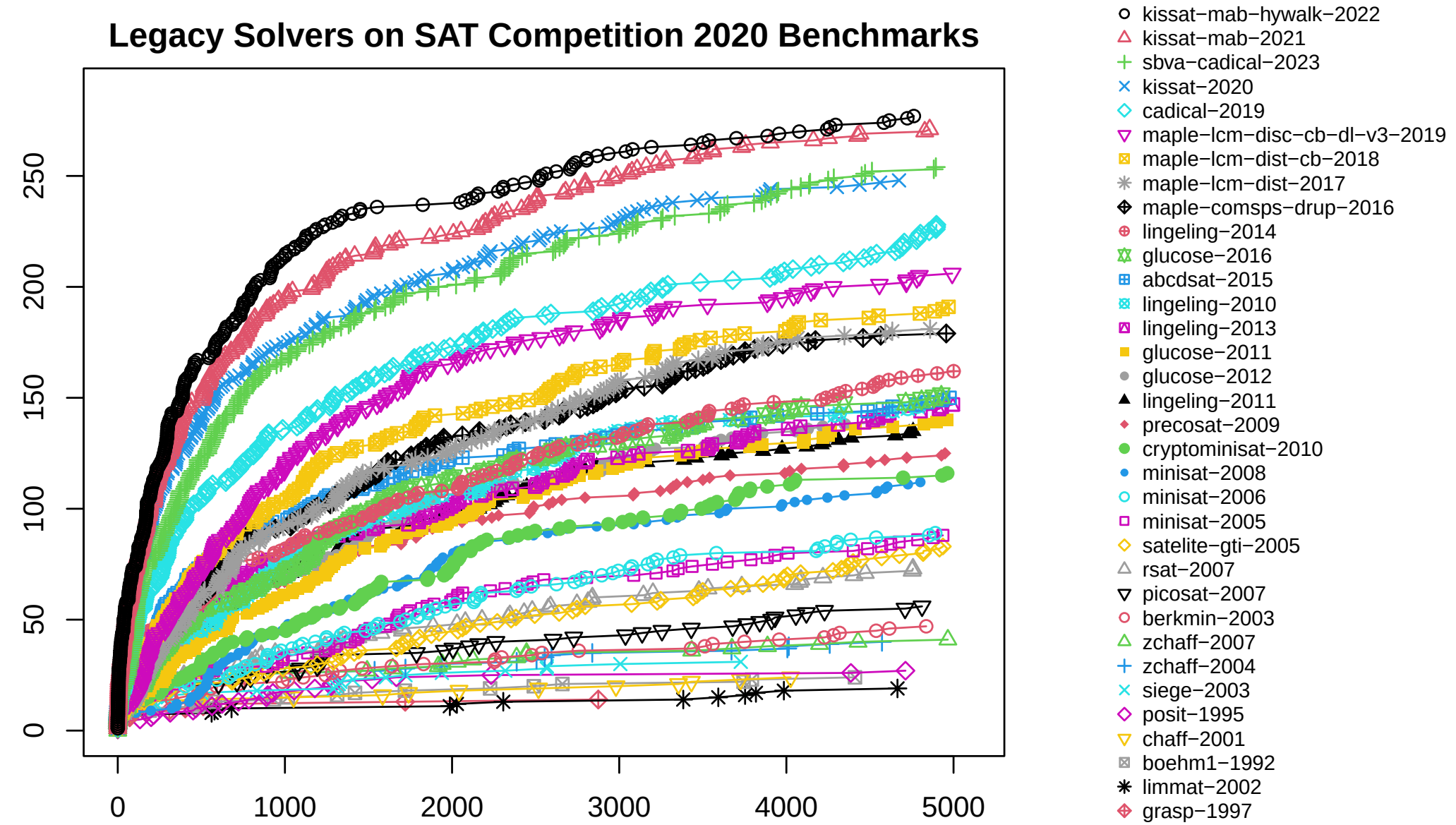
# Legacy Solvers — SAT Competition 2022

| solver | solved | sat | uns | fld | to | s11 | s6 | unk | time | space | max | best | uniq |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kissat-mab-2021 | 284 | 138 | 146 | 116 | 116 | 0 | 0 | 0 | 265782 | 150888 | 8560 | 22 | 0 |
| kissat-mab-hywalk-2022 | 281 | 141 | 140 | 119 | 119 | 0 | 0 | 0 | 243481 | 144848 | 5074 | 24 | 2 |
| kissat-2020 | 276 | 133 | 143 | 124 | 124 | 0 | 0 | 0 | 250172 | 140684 | 5800 | 29 | 3 |
| sbva-cadical-2023 | 272 | 139 | 133 | 128 | 128 | 0 | 0 | 0 | 237023 | 863369 | 40021 | 26 | 1 |
| cadical-2019 | 266 | 130 | 136 | 134 | 134 | 0 | 0 | 0 | 226275 | 338834 | 15287 | 35 | 1 |
| maple-lcm-disc-cb-dl-v3-2019 | 245 | 114 | 131 | 155 | 155 | 0 | 0 | 0 | 240050 | 252515 | 15342 | 4 | 0 |
| maple-lcm-dist-cb-2018 | 237 | 107 | 130 | 163 | 163 | 0 | 0 | 0 | 278238 | 241274 | 15342 | 14 | 1 |
| maple-lcm-dist-2017 | 237 | 109 | 128 | 163 | 157 | 6 | 0 | 0 | 282569 | 232392 | 15342 | 11 | 0 |
| maple-comsps-drup-2016 | 237 | 109 | 128 | 163 | 163 | 0 | 0 | 0 | 296217 | 254699 | 13707 | 27 | 0 |
| abcdsat-2015 | 222 | 102 | 120 | 178 | 175 | 1 | 2 | 0 | 218955 | 160324 | 11921 | 26 | 7 |
| glucose-2016 | 208 | 93 | 115 | 192 | 192 | 0 | 0 | 0 | 220600 | 150531 | 11923 | 1 | 0 |
| lingeling-2014 | 205 | 98 | 107 | 195 | 195 | 0 | 0 | 0 | 229105 | 153486 | 6317 | 2 | 0 |
| lingeling-2013 | 202 | 86 | 116 | 198 | 198 | 0 | 0 | 0 | 249622 | 124551 | 6233 | 4 | 0 |
| glucose-2012 | 201 | 88 | 113 | 199 | 198 | 0 | 0 | 1 | 225987 | 112212 | 5424 | 8 | 0 |
| glucose-2011 | 191 | 85 | 106 | 209 | 209 | 0 | 0 | 0 | 189747 | 109528 | 7737 | 17 | 0 |
| minisat-2008 | 190 | 91 | 99 | 210 | 210 | 0 | 0 | 0 | 210046 | 194259 | 11139 | 12 | 0 |
| lingeling-2011 | 184 | 89 | 95 | 216 | 211 | 1 | 0 | 4 | 227743 | 92008 | 4111 | 5 | 0 |
| lingeling-2010 | 181 | 82 | 99 | 219 | 211 | 0 | 0 | 8 | 173349 | 98203 | 6965 | 3 | 0 |
| precosat-2009 | 173 | 85 | 88 | 227 | 226 | 0 | 0 | 1 | 211820 | 258453 | 21011 | 10 | 0 |
| cryptominisat-2010 | 170 | 74 | 96 | 230 | 194 | 0 | 0 | 36 | 158503 | 130699 | 6645 | 14 | 1 |
| satelite-gti-2005 | 148 | 72 | 76 | 252 | 252 | 0 | 0 | 0 | 191724 | 180730 | 18383 | 1 | 0 |
| minisat-2006 | 147 | 64 | 83 | 253 | 253 | 0 | 0 | 0 | 131637 | 100257 | 11749 | 4 | 0 |
| rsat-2007 | 140 | 69 | 71 | 260 | 247 | 0 | 0 | 13 | 170097 | 151735 | 18921 | 2 | 1 |
| minisat-2005 | 135 | 60 | 75 | 265 | 254 | 0 | 0 | 11 | 118366 | 110412 | 11838 | 6 | 0 |
| picosat-2007 | 112 | 57 | 55 | 288 | 273 | 0 | 0 | 15 | 146944 | 37585 | 3879 | 0 | 0 |
| berkmin-2003 | 77 | 36 | 41 | 323 | 304 | 0 | 0 | 19 | 77844 | 17913 | 4066 | 0 | 0 |
| siege-2003 | 56 | 42 | 14 | 344 | 242 | 0 | 0 | 102 | 82966 | 15819 | 3385 | 2 | 0 |
| limmat-2002 | 49 | 24 | 25 | 351 | 324 | 0 | 27 | 0 | 61160 | 119707 | 15146 | 7 | 0 |
| chaff-2001 | 47 | 26 | 21 | 353 | 353 | 0 | 0 | 0 | 63674 | 91987 | 20260 | 0 | 0 |
| zchaff-2007 | 34 | 24 | 10 | 366 | 281 | 0 | 0 | 85 | 41662 | 9359 | 995 | 3 | 0 |
| zchaff-2004 | 32 | 23 | 9 | 368 | 283 | 0 | 0 | 85 | 32304 | 7984 | 875 | 0 | 0 |
| posit-1995 | 24 | 5 | 19 | 376 | 234 | 0 | 0 | 142 | 27943 | 830 | 270 | 1 | 0 |
| boehm1-1992 | 14 | 11 | 3 | 386 | 381 | 5 | 0 | 0 | 21429 | 38911 | 35939 | 0 | 0 |
| grasp-1997 | 7 | 6 | 1 | 393 | 393 | 0 | 0 | 0 | 4156 | 90404 | 83832 | 1 | 0 |


Legacy Solvers on SAT Competition 2021 Benchmarks
0
50
100
150
200
250
300
0
1000
2000
3000
4000
5000
kissat−mab−hywalk−2022
kissat−mab−2021
kissat−2020
sbva−cadical−2023
cadical−2019
maple−lcm−disc−cb−dl−v3−2019
maple−lcm−dist−2017
maple−lcm−dist−cb−2018
maple−comsps−drup−2016
glucose−2016
abcdsat−2015
lingeling−2014
glucose−2012
lingeling−2013
lingeling−2011
glucose−2011
minisat−2008
lingeling−2010
precosat−2009
cryptominisat−2010
minisat−2005
minisat−2006
rsat−2007
satelite−gti−2005
picosat−2007
berkmin−2003
siege−2003
boehm1−1992
chaff−2001
zchaff−2007
zchaff−2004
posit−1995
limmat−2002
grasp−1997

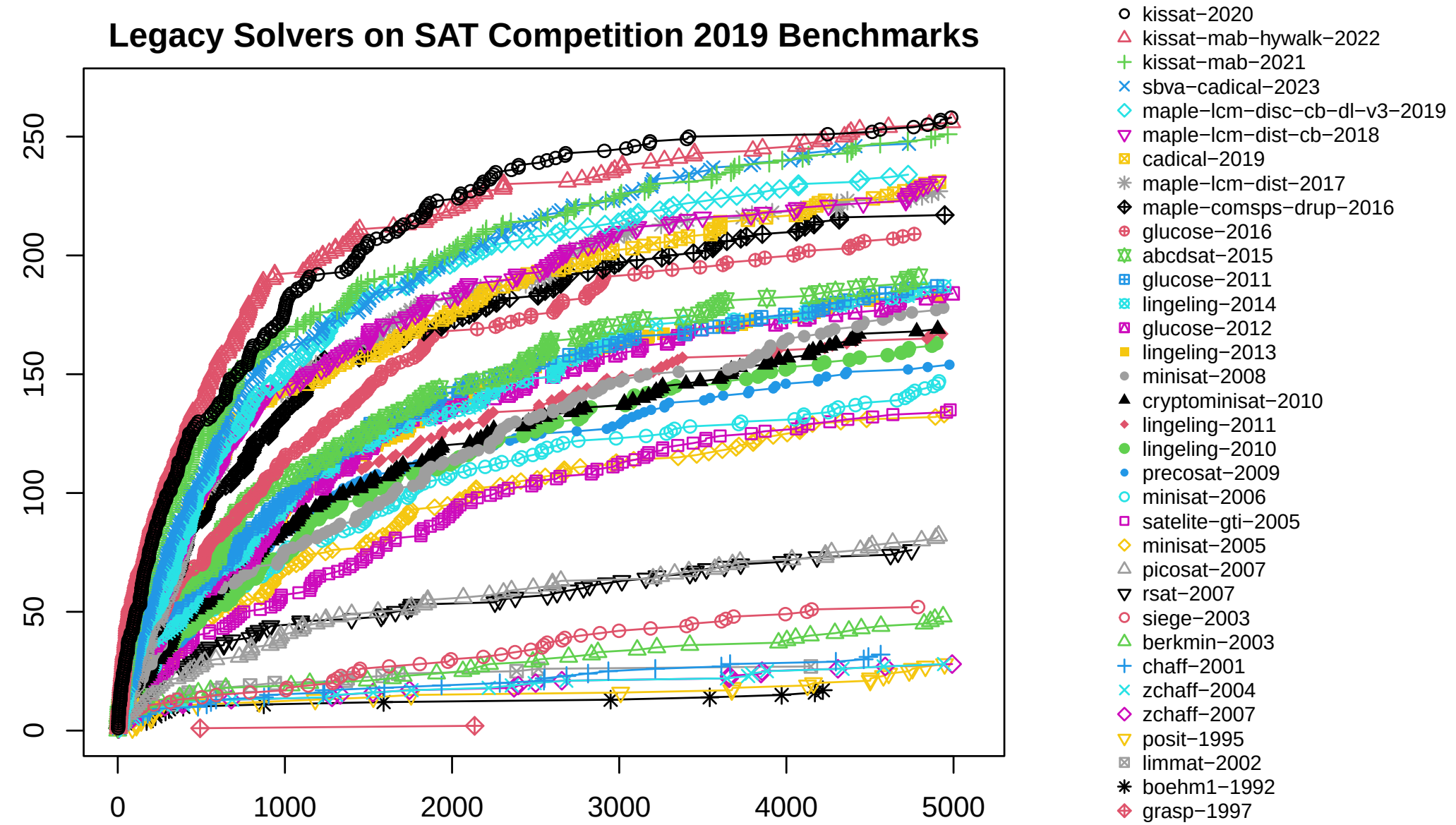
# Legacy Solvers — SAT Competition 2021

| solver | solved | sat | uns | fld | to | mo | s11 | s6 | unk | time | space | max | best | uniq |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kissat-mab-hywalk-2022 | 290 | 148 | 142 | 110 | 110 | 0 | 0 | 0 | 0 | 220938 | 67710 | 2362 | 32 | 4 |
| kissat-mab-2021 | 284 | 143 | 141 | 116 | 116 | 0 | 0 | 0 | 0 | 248861 | 67659 | 2405 | 23 | 0 |
| kissat-2020 | 276 | 127 | 149 | 124 | 124 | 0 | 0 | 0 | 0 | 249290 | 71045 | 2478 | 48 | 2 |
| sbva-cadical-2023 | 274 | 126 | 148 | 126 | 126 | 0 | 0 | 0 | 0 | 233158 | 459202 | 43138 | 27 | 2 |
| cadical-2019 | 256 | 121 | 135 | 144 | 144 | 0 | 0 | 0 | 0 | 271434 | 153413 | 4331 | 15 | 1 |
| maple-lcm-disc-cb-dl-v3-2019 | 244 | 109 | 135 | 156 | 156 | 0 | 0 | 0 | 0 | 255184 | 95426 | 2842 | 8 | 1 |
| maple-lcm-dist-2017 | 242 | 104 | 138 | 158 | 158 | 0 | 0 | 0 | 0 | 291999 | 101497 | 3106 | 6 | 0 |
| maple-lcm-dist-cb-2018 | 236 | 103 | 133 | 164 | 164 | 0 | 0 | 0 | 0 | 254683 | 95630 | 2885 | 11 | 0 |
| maple-comsps-drup-2016 | 228 | 101 | 127 | 172 | 172 | 0 | 0 | 0 | 0 | 226324 | 84985 | 2644 | 21 | 0 |
| glucose-2016 | 213 | 91 | 122 | 187 | 187 | 0 | 0 | 0 | 0 | 259282 | 65250 | 2236 | 21 | 2 |
| abcdsat-2015 | 211 | 90 | 121 | 189 | 189 | 0 | 0 | 0 | 0 | 241145 | 76009 | 3206 | 13 | 2 |
| lingeling-2014 | 196 | 85 | 111 | 204 | 199 | 0 | 0 | 0 | 5 | 211676 | 62424 | 4557 | 12 | 0 |
| glucose-2012 | 193 | 87 | 106 | 207 | 207 | 0 | 0 | 0 | 0 | 254867 | 70702 | 16696 | 7 | 0 |
| lingeling-2013 | 191 | 75 | 116 | 209 | 204 | 0 | 0 | 0 | 5 | 233513 | 69223 | 4599 | 12 | 0 |
| lingeling-2011 | 189 | 71 | 118 | 211 | 206 | 0 | 0 | 0 | 5 | 224258 | 59429 | 1612 | 4 | 1 |
| glucose-2011 | 184 | 80 | 104 | 216 | 216 | 0 | 0 | 0 | 0 | 219112 | 52933 | 1991 | 8 | 0 |
| minisat-2008 | 184 | 86 | 98 | 216 | 216 | 0 | 0 | 0 | 0 | 220271 | 104674 | 4767 | 2 | 0 |
| lingeling-2010 | 167 | 75 | 92 | 233 | 225 | 0 | 0 | 0 | 8 | 177092 | 43102 | 1628 | 5 | 0 |
| precosat-2009 | 162 | 75 | 87 | 238 | 232 | 0 | 0 | 0 | 6 | 191373 | 78727 | 3872 | 12 | 0 |
| cryptominisat-2010 | 162 | 67 | 95 | 238 | 225 | 0 | 1 | 0 | 12 | 212116 | 86447 | 3965 | 0 | 0 |
| minisat-2005 | 141 | 56 | 85 | 259 | 259 | 0 | 0 | 0 | 0 | 178458 | 57438 | 2616 | 8 | 0 |
| minisat-2006 | 138 | 55 | 83 | 262 | 262 | 0 | 0 | 0 | 0 | 199748 | 45593 | 1903 | 4 | 0 |
| rsat-2007 | 126 | 64 | 62 | 274 | 262 | 0 | 0 | 0 | 12 | 174228 | 67631 | 2517 | 3 | 0 |
| satelite-gti-2005 | 118 | 51 | 67 | 282 | 282 | 0 | 0 | 0 | 0 | 146521 | 35336 | 2424 | 2 | 0 |
| picosat-2007 | 114 | 50 | 64 | 286 | 278 | 0 | 0 | 0 | 8 | 137483 | 20636 | 1401 | 0 | 0 |
| berkmin-2003 | 69 | 25 | 44 | 331 | 282 | 0 | 0 | 0 | 49 | 97356 | 6934 | 699 | 6 | 0 |
| siege-2003 | 65 | 23 | 42 | 335 | 304 | 0 | 0 | 0 | 31 | 89911 | 7395 | 662 | 4 | 0 |
| boehm1-1992 | 57 | 27 | 30 | 343 | 334 | 0 | 9 | 0 | 0 | 26316 | 7786 | 2391 | 9 | 2 |
| chaff-2001 | 51 | 22 | 29 | 349 | 349 | 0 | 0 | 0 | 0 | 60342 | 26297 | 3396 | 1 | 0 |
| zchaff-2007 | 49 | 20 | 29 | 351 | 303 | 0 | 0 | 0 | 48 | 43681 | 8821 | 1024 | 2 | 0 |
| zchaff-2004 | 48 | 20 | 28 | 352 | 304 | 0 | 0 | 0 | 48 | 42284 | 8316 | 1024 | 1 | 0 |
| posit-1995 | 35 | 13 | 22 | 365 | 242 | 0 | 0 | 0 | 123 | 35189 | 5986 | 612 | 2 | 0 |
| limmat-2002 | 35 | 15 | 20 | 365 | 333 | 0 | 0 | 32 | 0 | 38441 | 30369 | 6439 | 1 | 0 |
| grasp-1997 | 18 | 7 | 11 | 382 | 380 | 2 | 0 | 0 | 0 | 9084 | 17288 | 5649 | 0 | 0 |


Legacy Solvers on SAT Competition 2020 Benchmarks
0
50
100
150
200
250
0
1000
2000
3000
4000
5000
kissat−mab−hywalk−2022
kissat−mab−2021
sbva−cadical−2023
kissat−2020
cadical−2019
maple−lcm−disc−cb−dl−v3−2019
maple−lcm−dist−cb−2018
maple−lcm−dist−2017
maple−comsps−drup−2016
lingeling−2014
glucose−2016
abcdsat−2015
lingeling−2010
lingeling−2013
glucose−2011
glucose−2012
lingeling−2011
precosat−2009
cryptominisat−2010
minisat−2008
minisat−2006
minisat−2005
satelite−gti−2005
rsat−2007
picosat−2007
berkmin−2003
zchaff−2007
zchaff−2004
siege−2003
posit−1995
chaff−2001
boehm1−1992
limmat−2002
grasp−1997

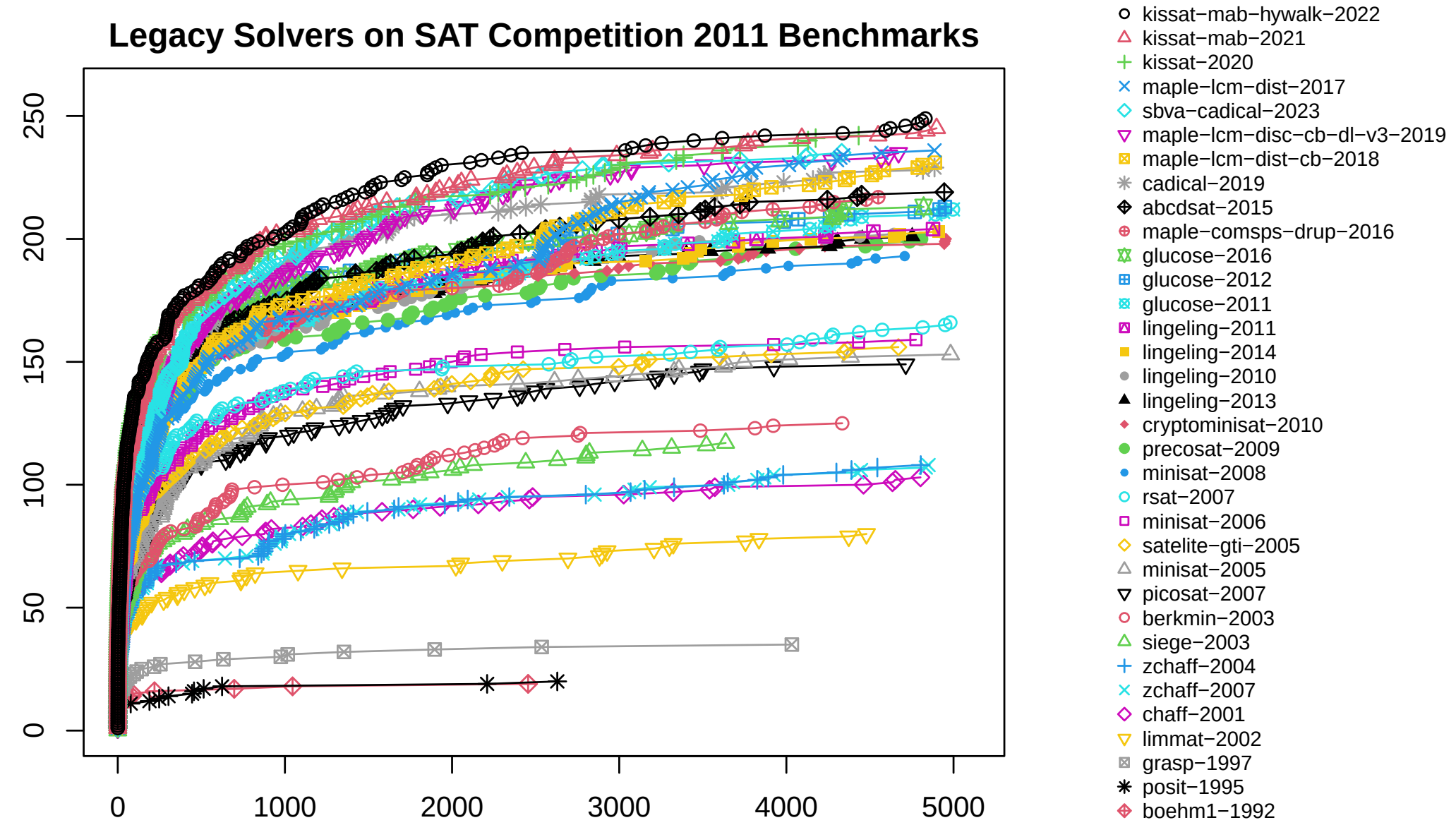
# Legacy Solvers — SAT Competition 2020

| solver | solved | sat | uns | fld | to | s11 | s6 | unk | time | space | max | best | uniq |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kissat-mab-hywalk-2022 | 277 | 158 | 119 | 123 | 123 | 0 | 0 | 0 | 214831 | 67973 | 4575 | 43 | 1 |
| kissat-mab-2021 | 271 | 153 | 118 | 129 | 129 | 0 | 0 | 0 | 237350 | 70471 | 4418 | 33 | 1 |
| sbva-cadical-2023 | 254 | 140 | 114 | 146 | 146 | 0 | 0 | 0 | 273014 | 460367 | 21075 | 26 | 2 |
| kissat-2020 | 248 | 129 | 119 | 152 | 152 | 0 | 0 | 0 | 215423 | 67972 | 5114 | 49 | 3 |
| cadical-2019 | 228 | 121 | 107 | 172 | 172 | 0 | 0 | 0 | 289405 | 164622 | 15513 | 12 | 1 |
| maple-lcm-disc-cb-dl-v3-2019 | 206 | 101 | 105 | 194 | 194 | 0 | 0 | 0 | 250736 | 119009 | 6249 | 4 | 0 |
| maple-lcm-dist-cb-2018 | 191 | 87 | 104 | 209 | 209 | 0 | 0 | 0 | 248563 | 115347 | 7066 | 13 | 0 |
| maple-lcm-dist-2017 | 181 | 82 | 99 | 219 | 219 | 0 | 0 | 0 | 251961 | 111687 | 7709 | 9 | 0 |
| maple-comsps-drup-2016 | 179 | 80 | 99 | 221 | 221 | 0 | 0 | 0 | 242450 | 96267 | 7023 | 18 | 0 |
| lingeling-2014 | 162 | 77 | 85 | 238 | 237 | 0 | 0 | 1 | 236450 | 85629 | 5188 | 12 | 0 |
| glucose-2016 | 151 | 66 | 85 | 249 | 249 | 0 | 0 | 0 | 205369 | 82043 | 8771 | 13 | 0 |
| abcdsat-2015 | 150 | 62 | 88 | 250 | 248 | 0 | 2 | 0 | 165385 | 81932 | 8631 | 19 | 3 |
| lingeling-2010 | 148 | 79 | 69 | 252 | 251 | 0 | 0 | 1 | 196825 | 42995 | 3214 | 9 | 0 |
| lingeling-2013 | 147 | 69 | 78 | 253 | 250 | 0 | 0 | 3 | 209945 | 75364 | 5174 | 7 | 0 |
| glucose-2011 | 140 | 59 | 81 | 260 | 260 | 0 | 0 | 0 | 215104 | 72376 | 7509 | 6 | 0 |
| glucose-2012 | 139 | 58 | 81 | 261 | 261 | 0 | 0 | 0 | 184454 | 73041 | 7526 | 10 | 0 |
| lingeling-2011 | 135 | 56 | 79 | 265 | 264 | 0 | 0 | 1 | 178888 | 49053 | 3583 | 2 | 0 |
| precosat-2009 | 125 | 66 | 59 | 275 | 270 | 0 | 0 | 5 | 164445 | 107984 | 16941 | 13 | 1 |
| cryptominisat-2010 | 116 | 46 | 70 | 284 | 269 | 5 | 0 | 10 | 188457 | 54342 | 3970 | 5 | 0 |
| minisat-2008 | 112 | 55 | 57 | 288 | 286 | 0 | 0 | 2 | 184661 | 74288 | 5491 | 3 | 0 |
| minisat-2006 | 89 | 41 | 48 | 311 | 311 | 0 | 0 | 0 | 149848 | 32579 | 4964 | 3 | 0 |
| minisat-2005 | 88 | 37 | 51 | 312 | 312 | 0 | 0 | 0 | 150632 | 39746 | 4872 | 4 | 0 |
| satelite-gti-2005 | 83 | 37 | 46 | 317 | 317 | 0 | 0 | 0 | 171435 | 48682 | 4675 | 3 | 0 |
| rsat-2007 | 73 | 40 | 33 | 327 | 312 | 0 | 0 | 15 | 111743 | 52400 | 6758 | 2 | 0 |
| picosat-2007 | 56 | 29 | 27 | 344 | 329 | 0 | 0 | 15 | 86906 | 11861 | 1316 | 2 | 0 |
| berkmin-2003 | 47 | 26 | 21 | 353 | 305 | 0 | 0 | 48 | 76380 | 5508 | 2283 | 2 | 0 |
| zchaff-2007 | 41 | 20 | 21 | 359 | 322 | 0 | 0 | 37 | 46576 | 14483 | 1419 | 6 | 0 |
| zchaff-2004 | 40 | 20 | 20 | 360 | 323 | 0 | 0 | 37 | 44151 | 13978 | 1422 | 4 | 0 |
| siege-2003 | 31 | 16 | 15 | 369 | 315 | 0 | 0 | 54 | 29099 | 5862 | 2101 | 2 | 0 |
| posit-1995 | 27 | 21 | 6 | 373 | 293 | 0 | 0 | 80 | 27805 | 549 | 90 | 4 | 1 |
| chaff-2001 | 24 | 13 | 11 | 376 | 376 | 0 | 0 | 0 | 27685 | 12899 | 4139 | 4 | 0 |
| boehm1-1992 | 24 | 18 | 6 | 376 | 361 | 15 | 0 | 0 | 27802 | 2712 | 1784 | 2 | 0 |
| limmat-2002 | 19 | 8 | 11 | 381 | 346 | 0 | 35 | 0 | 31379 | 17802 | 8680 | 3 | 0 |
| grasp-1997 | 14 | 10 | 4 | 386 | 386 | 0 | 0 | 0 | 6758 | 14498 | 4218 | 3 | 0 |


Legacy Solvers on SAT Competition 2019 Benchmarks
0
50
100
150
200
250
0
1000
2000
3000
4000
5000
kissat−2020
kissat−mab−hywalk−2022
kissat−mab−2021
sbva−cadical−2023
maple−lcm−disc−cb−dl−v3−2019
maple−lcm−dist−cb−2018
cadical−2019
maple−lcm−dist−2017
maple−comsps−drup−2016
glucose−2016
abcdsat−2015
glucose−2011
lingeling−2014
glucose−2012
lingeling−2013
minisat−2008
cryptominisat−2010
lingeling−2011
lingeling−2010
precosat−2009
minisat−2006
satelite−gti−2005
minisat−2005
picosat−2007
rsat−2007
siege−2003
berkmin−2003
chaff−2001
zchaff−2004
zchaff−2007
posit−1995
limmat−2002
boehm1−1992
grasp−1997

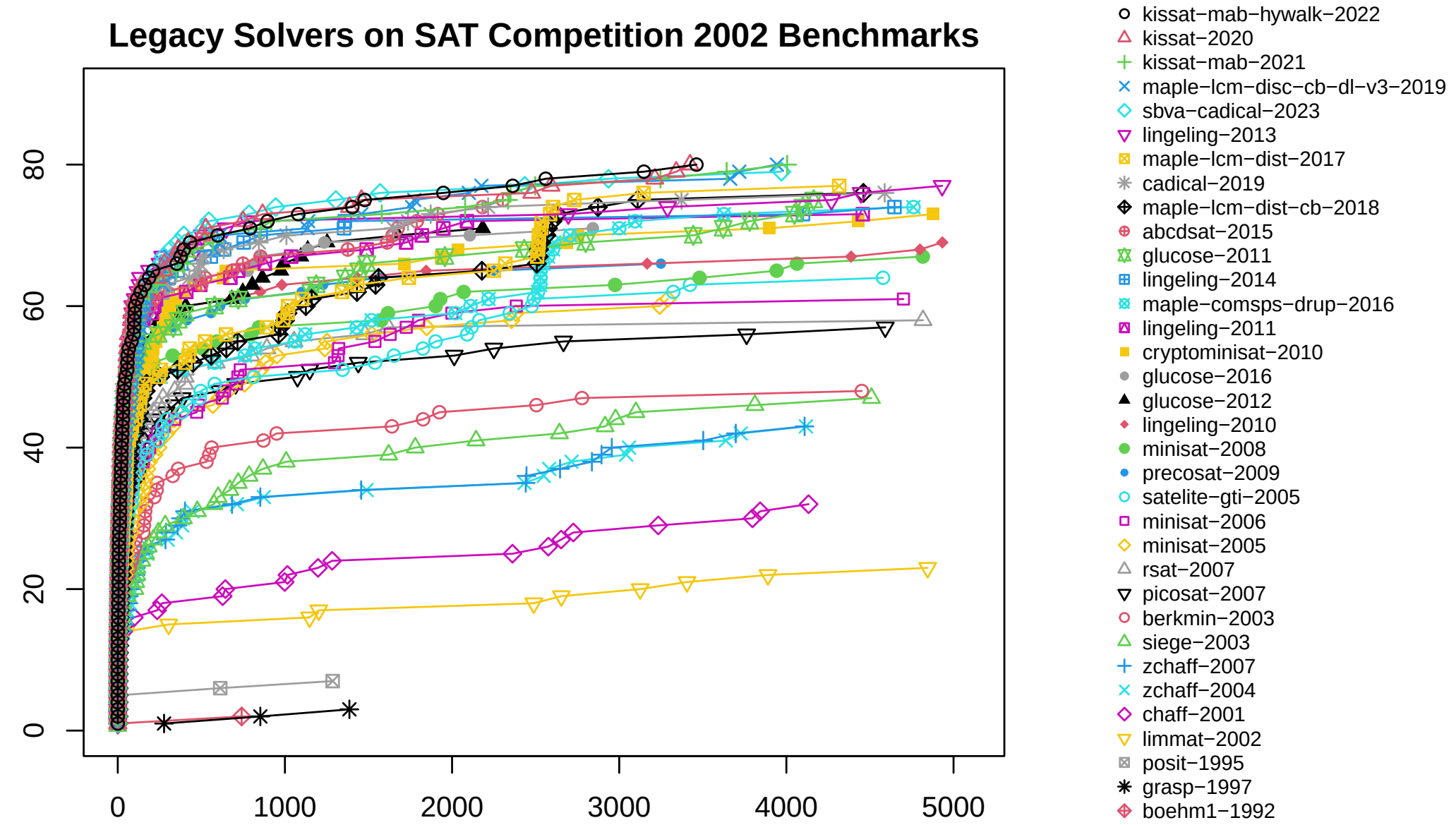
# Legacy Solvers — SAT Competition 2019

| solver | solved | sat | uns | fld | to | s11 | s6 | unk | time | space | max | best | uniq |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kissat-2020 | 258 | 158 | 100 | 142 | 142 | 0 | 0 | 0 | 231717 | 34028 | 4067 | 38 | 2 |
| kissat-mab-hywalk-2022 | 256 | 163 | 93 | 144 | 144 | 0 | 0 | 0 | 221039 | 31599 | 4128 | 27 | 0 |
| kissat-mab-2021 | 251 | 158 | 93 | 149 | 149 | 0 | 0 | 0 | 264842 | 33285 | 4233 | 17 | 0 |
| sbva-cadical-2023 | 247 | 149 | 98 | 153 | 153 | 0 | 0 | 0 | 262386 | 541927 | 53273 | 20 | 2 |
| maple-lcm-disc-cb-dl-v3-2019 | 234 | 140 | 94 | 166 | 166 | 0 | 0 | 0 | 238701 | 82240 | 8922 | 16 | 0 |
| maple-lcm-dist-cb-2018 | 231 | 136 | 95 | 169 | 169 | 0 | 0 | 0 | 268028 | 74120 | 8923 | 12 | 0 |
| cadical-2019 | 231 | 141 | 90 | 169 | 169 | 0 | 0 | 0 | 277271 | 72814 | 8698 | 16 | 1 |
| maple-lcm-dist-2017 | 227 | 130 | 97 | 173 | 173 | 0 | 0 | 0 | 252583 | 78596 | 8923 | 15 | 1 |
| maple-comsps-drup-2016 | 217 | 125 | 92 | 183 | 183 | 0 | 0 | 0 | 244148 | 67470 | 8105 | 16 | 1 |
| glucose-2016 | 209 | 124 | 85 | 191 | 191 | 0 | 0 | 0 | 257139 | 58077 | 7135 | 5 | 0 |
| abcdsat-2015 | 191 | 111 | 80 | 209 | 207 | 1 | 1 | 0 | 240830 | 59965 | 7105 | 20 | 0 |
| glucose-2011 | 187 | 112 | 75 | 213 | 213 | 0 | 0 | 0 | 246218 | 49368 | 4130 | 7 | 0 |
| lingeling-2014 | 187 | 110 | 77 | 213 | 213 | 0 | 0 | 0 | 257272 | 41979 | 5251 | 12 | 1 |
| glucose-2012 | 184 | 108 | 76 | 216 | 216 | 0 | 0 | 0 | 257042 | 46254 | 4129 | 15 | 0 |
| lingeling-2013 | 183 | 113 | 70 | 217 | 217 | 0 | 0 | 0 | 239510 | 44934 | 5234 | 4 | 0 |
| minisat-2008 | 178 | 118 | 60 | 222 | 222 | 0 | 0 | 0 | 292642 | 74993 | 5748 | 10 | 0 |
| cryptominisat-2010 | 169 | 96 | 73 | 231 | 226 | 0 | 0 | 5 | 250363 | 43261 | 8154 | 7 | 0 |
| lingeling-2011 | 167 | 106 | 61 | 233 | 233 | 0 | 0 | 0 | 213277 | 40642 | 4349 | 3 | 0 |
| lingeling-2010 | 163 | 112 | 51 | 237 | 237 | 0 | 0 | 0 | 243999 | 30599 | 3997 | 1 | 0 |
| precosat-2009 | 154 | 101 | 53 | 246 | 246 | 0 | 0 | 0 | 207678 | 49620 | 11147 | 8 | 2 |
| minisat-2006 | 147 | 97 | 50 | 253 | 253 | 0 | 0 | 0 | 218457 | 38943 | 5965 | 6 | 0 |
| satelite-gti-2005 | 135 | 91 | 44 | 265 | 265 | 0 | 0 | 0 | 210868 | 50667 | 11602 | 3 | 0 |
| minisat-2005 | 133 | 89 | 44 | 267 | 267 | 0 | 0 | 0 | 190479 | 42921 | 6450 | 5 | 0 |
| picosat-2007 | 82 | 66 | 16 | 318 | 316 | 0 | 0 | 2 | 133212 | 12288 | 2532 | 4 | 0 |
| rsat-2007 | 76 | 60 | 16 | 324 | 319 | 0 | 0 | 5 | 105305 | 29981 | 9670 | 3 | 0 |
| siege-2003 | 52 | 40 | 12 | 348 | 314 | 0 | 0 | 34 | 92321 | 6932 | 664 | 0 | 0 |
| berkmin-2003 | 48 | 31 | 17 | 352 | 342 | 0 | 0 | 10 | 97606 | 8075 | 3276 | 0 | 0 |
| chaff-2001 | 32 | 30 | 2 | 368 | 368 | 0 | 0 | 0 | 54936 | 13421 | 1058 | 0 | 0 |
| zchaff-2004 | 28 | 19 | 9 | 372 | 353 | 0 | 0 | 19 | 46945 | 5731 | 567 | 2 | 0 |
| zchaff-2007 | 28 | 19 | 9 | 372 | 353 | 0 | 0 | 19 | 47120 | 5705 | 567 | 0 | 0 |
| posit-1995 | 28 | 11 | 17 | 372 | 312 | 0 | 0 | 60 | 63660 | 533 | 269 | 1 | 0 |
| limmat-2002 | 27 | 27 | 0 | 373 | 346 | 0 | 27 | 0 | 20974 | 26296 | 8064 | 3 | 0 |
| boehm1-1992 | 17 | 6 | 11 | 383 | 375 | 8 | 0 | 0 | 23149 | 212 | 162 | 2 | 0 |
| grasp-1997 | 2 | 2 | 0 | 398 | 398 | 0 | 0 | 0 | 2627 | 732 | 370 | 0 | 0 |


Legacy Solvers on SAT Competition 2011 Benchmarks
0
50
100
150
200
250
0
1000
2000
3000
4000
5000
kissat−mab−hywalk−2022
kissat−mab−2021
kissat−2020
maple−lcm−dist−2017
sbva−cadical−2023
maple−lcm−disc−cb−dl−v3−2019
maple−lcm−dist−cb−2018
cadical−2019
abcdsat−2015
maple−comsps−drup−2016
glucose−2016
glucose−2012
glucose−2011
lingeling−2011
lingeling−2014
lingeling−2010
lingeling−2013
cryptominisat−2010
precosat−2009
minisat−2008
rsat−2007
minisat−2006
satelite−gti−2005
minisat−2005
picosat−2007
berkmin−2003
siege−2003
zchaff−2004
zchaff−2007
chaff−2001
limmat−2002
grasp−1997
posit−1995
boehm1−1992

# Legacy Solvers — SAT Competition 2011

| solver | solved | sat | uns | fld | to | s11 | s6 | unk | time | space | max | best | uniq |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kissat-mab-hywalk-2022 | 249 | 110 | 139 | 51 | 51 | 0 | 0 | 0 | 136690 | 29157 | 1748 | 26 | 1 |
| kissat-mab-2021 | 245 | 108 | 137 | 55 | 55 | 0 | 0 | 0 | 137092 | 31230 | 1749 | 17 | 0 |
| kissat-2020 | 242 | 102 | 140 | 58 | 58 | 0 | 0 | 0 | 138677 | 30654 | 1723 | 31 | 0 |
| maple-lcm-dist-2017 | 236 | 101 | 135 | 64 | 64 | 0 | 0 | 0 | 217545 | 128294 | 14846 | 4 | 0 |
| sbva-cadical-2023 | 235 | 102 | 133 | 65 | 65 | 0 | 0 | 0 | 124395 | 528125 | 29371 | 16 | 1 |
| maple-lcm-disc-cb-dl-v3-2019 | 235 | 102 | 133 | 65 | 65 | 0 | 0 | 0 | 142675 | 95658 | 5522 | 13 | 0 |
| maple-lcm-dist-cb-2018 | 231 | 99 | 132 | 69 | 69 | 0 | 0 | 0 | 192404 | 127379 | 12914 | 6 | 0 |
| cadical-2019 | 229 | 97 | 132 | 71 | 71 | 0 | 0 | 0 | 131644 | 70639 | 4817 | 19 | 0 |
| abcdsat-2015 | 219 | 92 | 127 | 81 | 79 | 0 | 2 | 0 | 131213 | 69415 | 4073 | 11 | 0 |
| maple-comsps-drup-2016 | 217 | 98 | 119 | 83 | 83 | 0 | 0 | 0 | 156551 | 57232 | 4958 | 8 | 0 |
| glucose-2016 | 213 | 93 | 120 | 87 | 87 | 0 | 0 | 0 | 109306 | 50482 | 4443 | 30 | 0 |
| glucose-2012 | 213 | 93 | 120 | 87 | 87 | 0 | 0 | 0 | 114492 | 48001 | 2832 | 22 | 0 |
| glucose-2011 | 212 | 93 | 119 | 88 | 88 | 0 | 0 | 0 | 148905 | 50432 | 2832 | 12 | 0 |
| lingeling-2011 | 204 | 90 | 114 | 96 | 96 | 0 | 0 | 0 | 109599 | 37195 | 2854 | 2 | 0 |
| lingeling-2014 | 203 | 91 | 112 | 97 | 97 | 0 | 0 | 0 | 113777 | 30264 | 2795 | 7 | 0 |
| lingeling-2010 | 202 | 98 | 104 | 98 | 98 | 0 | 0 | 0 | 112522 | 26464 | 2190 | 13 | 1 |
| lingeling-2013 | 201 | 94 | 107 | 99 | 99 | 0 | 0 | 0 | 105817 | 31462 | 2675 | 6 | 0 |
| cryptominisat-2010 | 200 | 85 | 115 | 100 | 97 | 0 | 0 | 3 | 115524 | 68605 | 5649 | 11 | 0 |
| precosat-2009 | 200 | 93 | 107 | 100 | 100 | 0 | 0 | 0 | 131686 | 89320 | 3451 | 7 | 0 |
| minisat-2008 | 193 | 94 | 99 | 107 | 107 | 0 | 0 | 0 | 120910 | 86809 | 10263 | 19 | 0 |
| rsat-2007 | 166 | 85 | 81 | 134 | 131 | 0 | 0 | 3 | 103143 | 68055 | 6931 | 1 | 0 |
| minisat-2006 | 159 | 83 | 76 | 141 | 141 | 0 | 0 | 0 | 69913 | 52669 | 7698 | 1 | 0 |
| satelite-gti-2005 | 156 | 76 | 80 | 144 | 144 | 0 | 0 | 0 | 86664 | 47973 | 2725 | 3 | 0 |
| minisat-2005 | 153 | 77 | 76 | 147 | 147 | 0 | 0 | 0 | 86498 | 52369 | 5116 | 11 | 0 |
| picosat-2007 | 149 | 77 | 72 | 151 | 151 | 0 | 0 | 0 | 87987 | 21297 | 1327 | 3 | 0 |
| berkmin-2003 | 125 | 58 | 67 | 175 | 169 | 0 | 0 | 6 | 73043 | 11192 | 559 | 8 | 0 |
| siege-2003 | 117 | 58 | 59 | 183 | 159 | 0 | 0 | 24 | 63728 | 12302 | 549 | 5 | 0 |
| zchaff-2004 | 108 | 51 | 57 | 192 | 174 | 0 | 0 | 18 | 86596 | 24272 | 1796 | 5 | 0 |
| zchaff-2007 | 108 | 51 | 57 | 192 | 175 | 0 | 0 | 17 | 86757 | 24408 | 1796 | 5 | 0 |
| chaff-2001 | 103 | 58 | 45 | 197 | 197 | 0 | 0 | 0 | 65514 | 42187 | 6074 | 6 | 0 |
| limmat-2002 | 80 | 46 | 34 | 220 | 162 | 0 | 58 | 0 | 54422 | 59747 | 5374 | 10 | 0 |
| grasp-1997 | 35 | 20 | 15 | 265 | 265 | 0 | 0 | 0 | 14049 | 17040 | 4787 | 3 | 0 |
| posit-1995 | 20 | 13 | 7 | 280 | 148 | 0 | 0 | 132 | 7705 | 293 | 65 | 1 | 0 |
| boehm1-1992 | 19 | 12 | 7 | 281 | 273 | 8 | 0 | 0 | 4708 | 1272 | 420 | 7 | 0 |


Legacy Solvers on SAT Competition 2002 Benchmarks
0
20
40
60
80
0
1000
2000
3000
4000
5000
kissat−mab−hywalk−2022
kissat−2020
kissat−mab−2021
maple−lcm−disc−cb−dl−v3−2019
sbva−cadical−2023
lingeling−2013
maple−lcm−dist−2017
cadical−2019
maple−lcm−dist−cb−2018
abcdsat−2015
glucose−2011
lingeling−2014
maple−comsps−drup−2016
lingeling−2011
cryptominisat−2010
glucose−2016
glucose−2012
lingeling−2010
minisat−2008
precosat−2009
satelite−gti−2005
minisat−2006
minisat−2005
rsat−2007
picosat−2007
berkmin−2003
siege−2003
zchaff−2007
zchaff−2004
chaff−2001
limmat−2002
posit−1995
grasp−1997
boehm1−1992

# Legacy Solvers — SAT Competition 2002

| solver | solved | sat | uns | fld | to | s6 | unk | time | space | max | best |
|---|---|---|---|---|---|---|---|---|---|---|---|
| kissat-mab-hywalk-2022 | 80 | 23 | 57 | 20 | 20 | 0 | 0 | 23532 | 2322 | 274 | 3 |
| kissat-2020 | 80 | 23 | 57 | 20 | 20 | 0 | 0 | 24087 | 2301 | 239 | 15 |
| kissat-mab-2021 | 80 | 23 | 57 | 20 | 20 | 0 | 0 | 28537 | 2393 | 284 | 0 |
| maple-lcm-disc-cb-dl-v3-2019 | 80 | 23 | 57 | 20 | 20 | 0 | 0 | 29251 | 7021 | 388 | 2 |
| sbva-cadical-2023 | 79 | 23 | 56 | 21 | 21 | 0 | 0 | 19124 | 48003 | 7555 | 6 |
| lingeling-2013 | 77 | 23 | 54 | 23 | 23 | 0 | 0 | 25243 | 3628 | 396 | 7 |
| maple-lcm-dist-2017 | 77 | 23 | 54 | 23 | 23 | 0 | 0 | 49480 | 6616 | 591 | 0 |
| cadical-2019 | 76 | 23 | 53 | 24 | 24 | 0 | 0 | 22059 | 5514 | 655 | 6 |
| maple-lcm-dist-cb-2018 | 76 | 23 | 53 | 24 | 24 | 0 | 0 | 49028 | 6123 | 388 | 0 |
| abcdsat-2015 | 75 | 23 | 52 | 25 | 25 | 0 | 0 | 20235 | 6637 | 721 | 9 |
| glucose-2011 | 75 | 23 | 52 | 25 | 25 | 0 | 0 | 41071 | 8788 | 1463 | 3 |
| lingeling-2014 | 74 | 23 | 51 | 26 | 26 | 0 | 0 | 17978 | 3163 | 322 | 1 |
| maple-comsps-drup-2016 | 74 | 23 | 51 | 26 | 26 | 0 | 0 | 53838 | 5841 | 533 | 3 |
| lingeling-2011 | 73 | 23 | 50 | 27 | 27 | 0 | 0 | 20054 | 3492 | 324 | 4 |
| cryptominisat-2010 | 73 | 23 | 50 | 27 | 27 | 0 | 0 | 31255 | 6569 | 686 | 1 |
| glucose-2016 | 71 | 23 | 48 | 29 | 29 | 0 | 0 | 13270 | 4868 | 530 | 9 |
| glucose-2012 | 71 | 23 | 48 | 29 | 29 | 0 | 0 | 15070 | 6237 | 785 | 8 |
| lingeling-2010 | 69 | 23 | 46 | 31 | 31 | 0 | 0 | 26986 | 2630 | 309 | 0 |
| minisat-2008 | 67 | 23 | 44 | 33 | 33 | 0 | 0 | 33261 | 8544 | 2990 | 2 |
| precosat-2009 | 66 | 23 | 43 | 34 | 34 | 0 | 0 | 14108 | 5550 | 723 | 3 |
| satelite-gti-2005 | 64 | 22 | 42 | 36 | 36 | 0 | 0 | 39026 | 6011 | 715 | 0 |
| minisat-2006 | 61 | 20 | 41 | 39 | 39 | 0 | 0 | 26616 | 6494 | 1149 | 0 |
| minisat-2005 | 61 | 21 | 40 | 39 | 39 | 0 | 0 | 27154 | 4318 | 771 | 1 |
| rsat-2007 | 58 | 22 | 36 | 42 | 42 | 0 | 0 | 15046 | 5191 | 524 | 0 |
| picosat-2007 | 57 | 23 | 34 | 43 | 43 | 0 | 0 | 23530 | 1961 | 424 | 1 |
| berkmin-2003 | 48 | 18 | 30 | 52 | 48 | 0 | 4 | 21435 | 1008 | 79 | 0 |
| siege-2003 | 47 | 16 | 31 | 53 | 49 | 0 | 4 | 33458 | 3345 | 249 | 0 |
| zchaff-2007 | 43 | 14 | 29 | 57 | 57 | 0 | 0 | 33368 | 3959 | 384 | 1 |
| zchaff-2004 | 43 | 14 | 29 | 57 | 57 | 0 | 0 | 34035 | 3919 | 383 | 0 |
| chaff-2001 | 32 | 13 | 19 | 68 | 0 | 0 | 68 | 31783 | 6727 | 930 | 0 |
| limmat-2002 | 23 | 12 | 11 | 77 | 70 | 7 | 0 | 23137 | 10536 | 3450 | 0 |
| posit-1995 | 7 | 5 | 2 | 93 | 65 | 0 | 28 | 1938 | 176 | 45 | 0 |
| grasp-1997 | 3 | 2 | 1 | 97 | 97 | 0 | 0 | 2516 | 1722 | 998 | 0 |
| boehm1-1992 | 2 | 0 | 2 | 98 | 98 | 0 | 0 | 742 | 4 | 2 | 0 |

# Related Work

- comparing SAT solvers for bit-vector solving [Duterte-SMT'20]
- incremental SAT for MaxSAT [KochemazovIgnatievMarques-Silva-SAT'21]
- SAT Heritage [AudemardPaulevéSimon-SAT'20]
- Hardware vs. Software progress in SAT solving [FichteHecherSzeider-CP'20]

We patched solvers to remove bugs / discrepancies and run them on the same platform on 7 years of competition benchmarks!

- we are missing some historic solvers: SATO, Satz, RelSAT, ...
- potential threats to validity that solvers are getting faster and faster

# Threats to Validity

- authors stake-holders of the competition
  - either as organizers or submitters
  - showing that solvers improved serves their agenda
  - careful experiment on 7 years of competition benchmarks
- previous competition benchmark bias
  - solvers are trained on past competition benchmarks
  - running old solvers on new benchmarks
  - progress also on unseen benchmarks

# Thanks go to ...


- Contributors to and supporters of the SAT competitions and POS workshops
  majority of the SAT solvers is available through competition webpages

- Colleagues who helped us to resurrect solvers:

  Jingchao Chen (abcdsat-2015); Eugene Goldberg, Yakov Novikov (berkmin-2003); Lintao Zhang, Matthew Moskewicz, Sharad Malik (chaff-2001); Hans Kleine Büning, Theodor Lettmann (boehm1-1992); João Marques-Silva (grasp-1997).

- Funding
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  - LIT AI Lab funded by the State of Upper Austria

- Karem Sakallah for his infinite patience in discussing progress in SAT solving

- Daniel Le Berre for coining the term “SAT Museum” in 2009

- participants of the POS’23 workshop at SAT’23

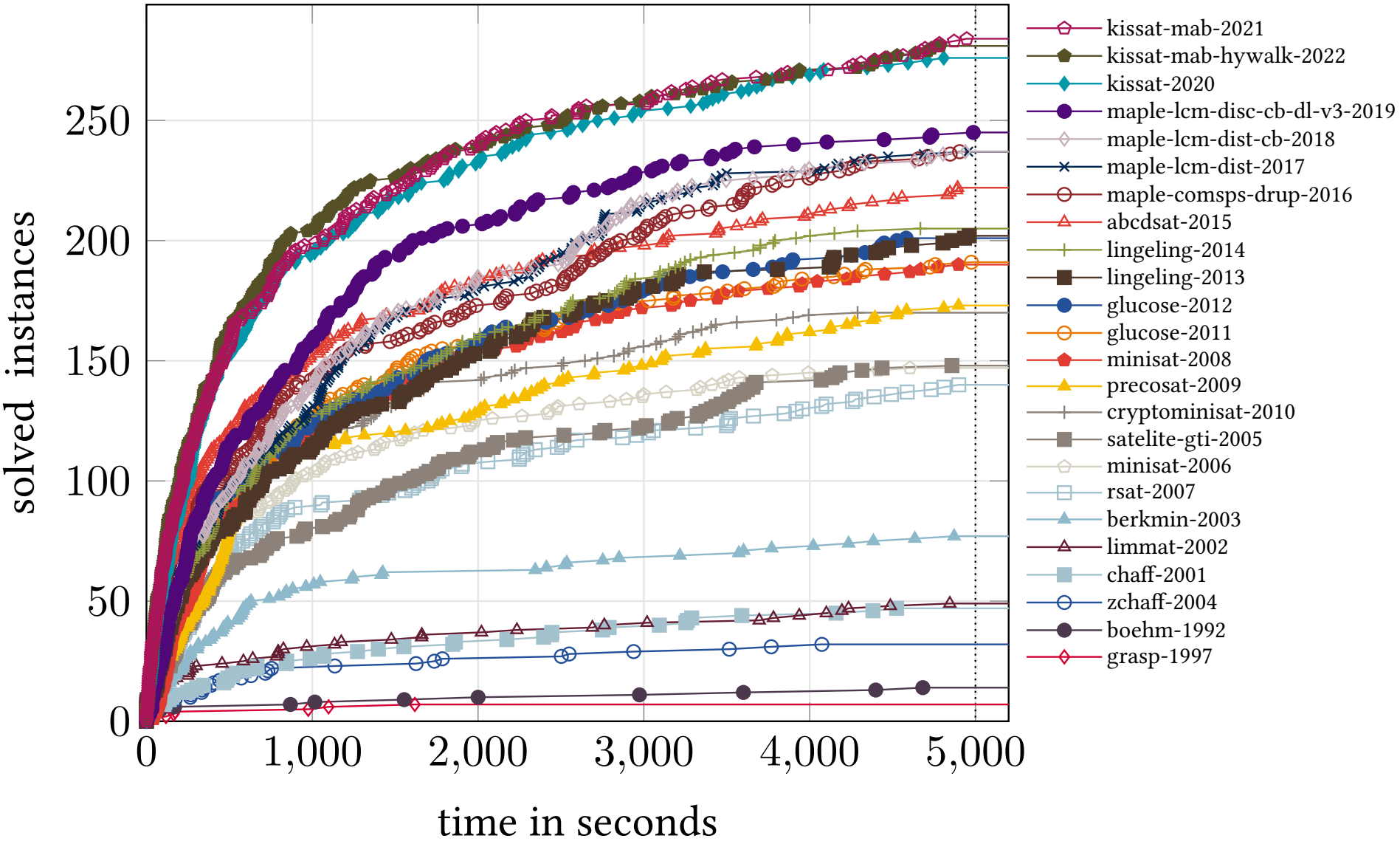
# Conclusion

- SAT solvers improved tremendously in the last decades
- empirically there are quantum leaps every 3-5 years
- features develop independently and excel when merged

**SAT solvers do get faster and faster!**

- partial understanding of the impact of solver features
- need to reassess their interaction and impact $\Rightarrow$ TabularaSAT
- what about improvement in other scenarios?
  - Model Checking (BMC, $k$-induction, IC3), MaxSAT, etc.
  - for backbones and SMT see our SAT'23 papers

# All-Time Winners — SAT Competition 2022 — Solved



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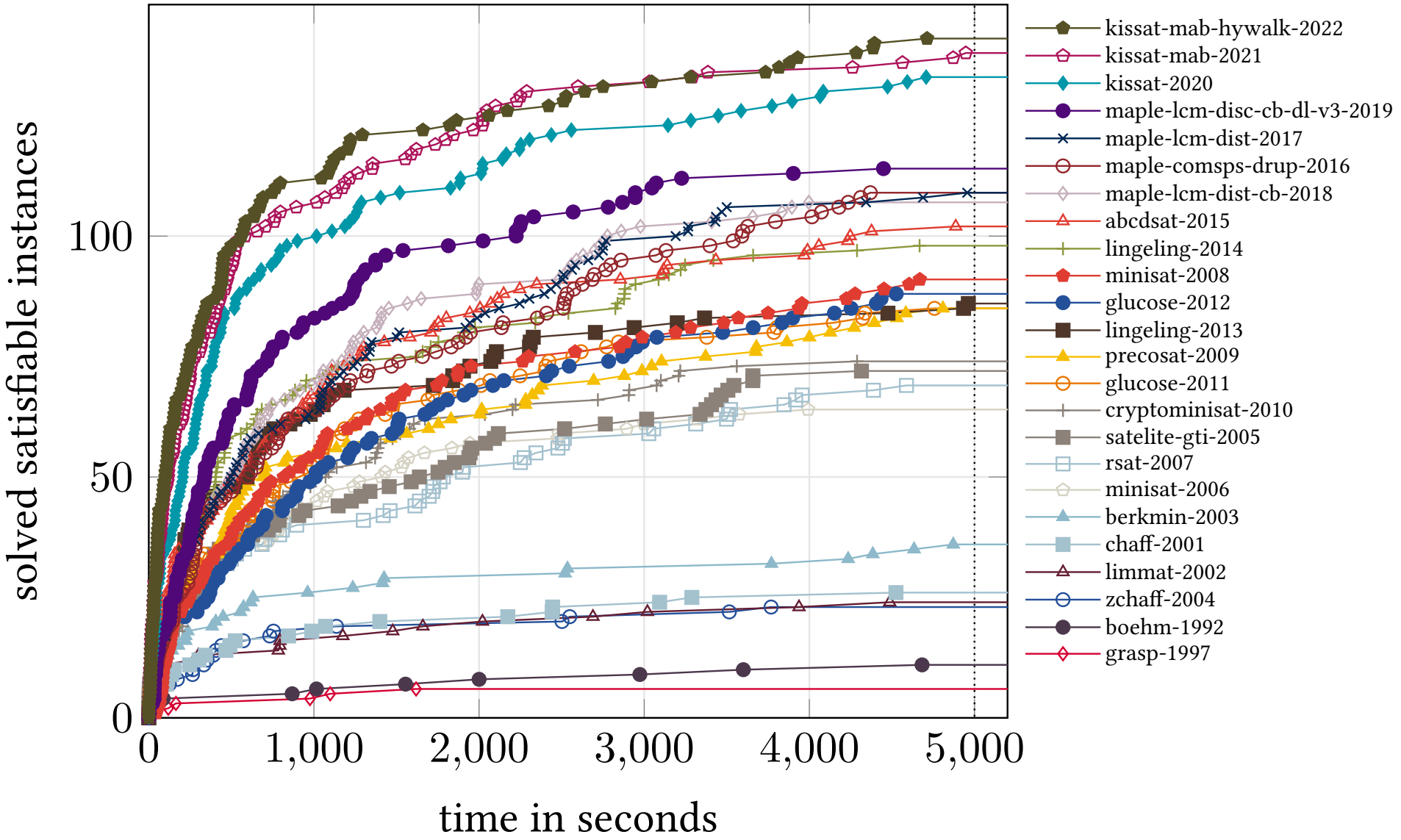

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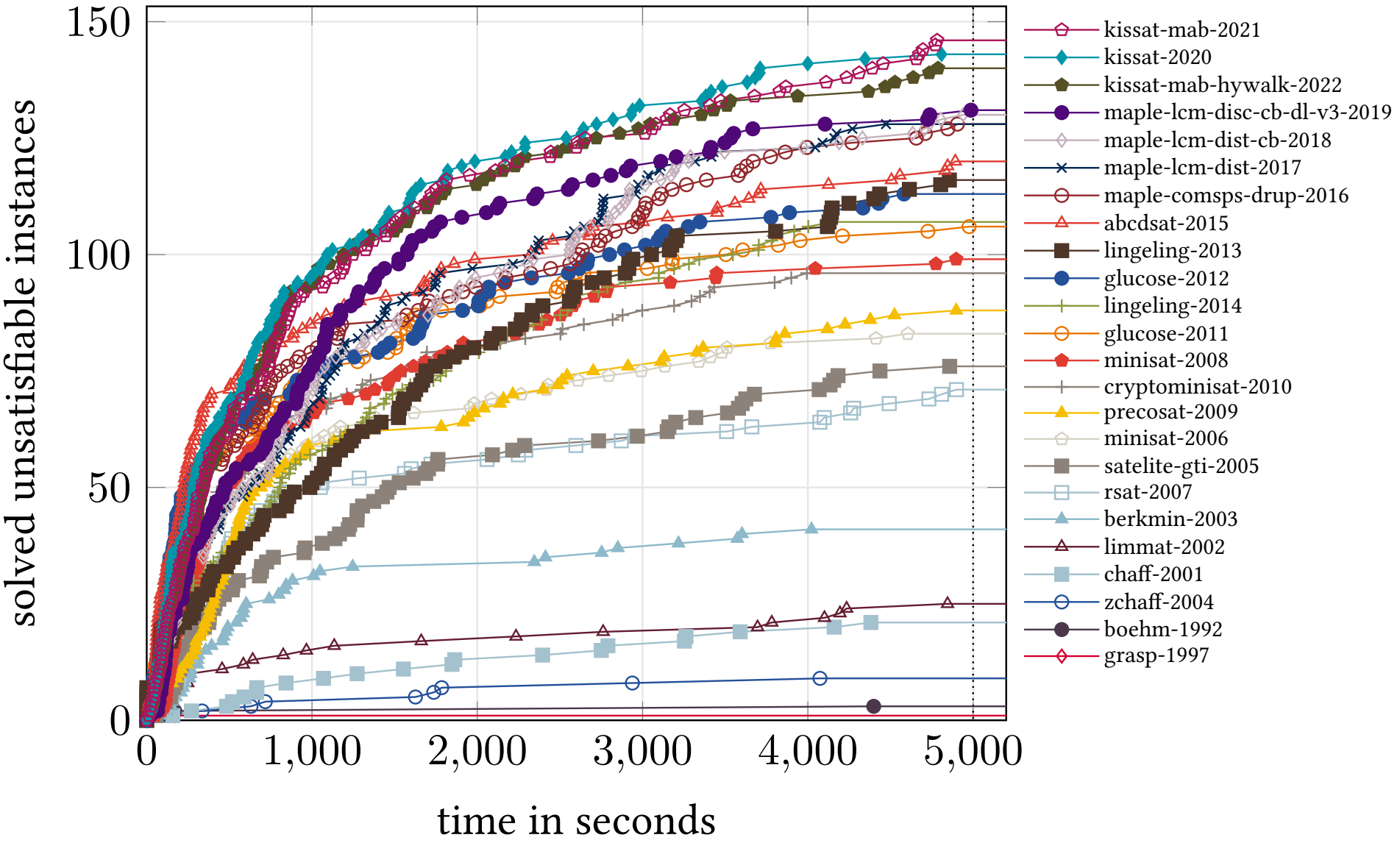

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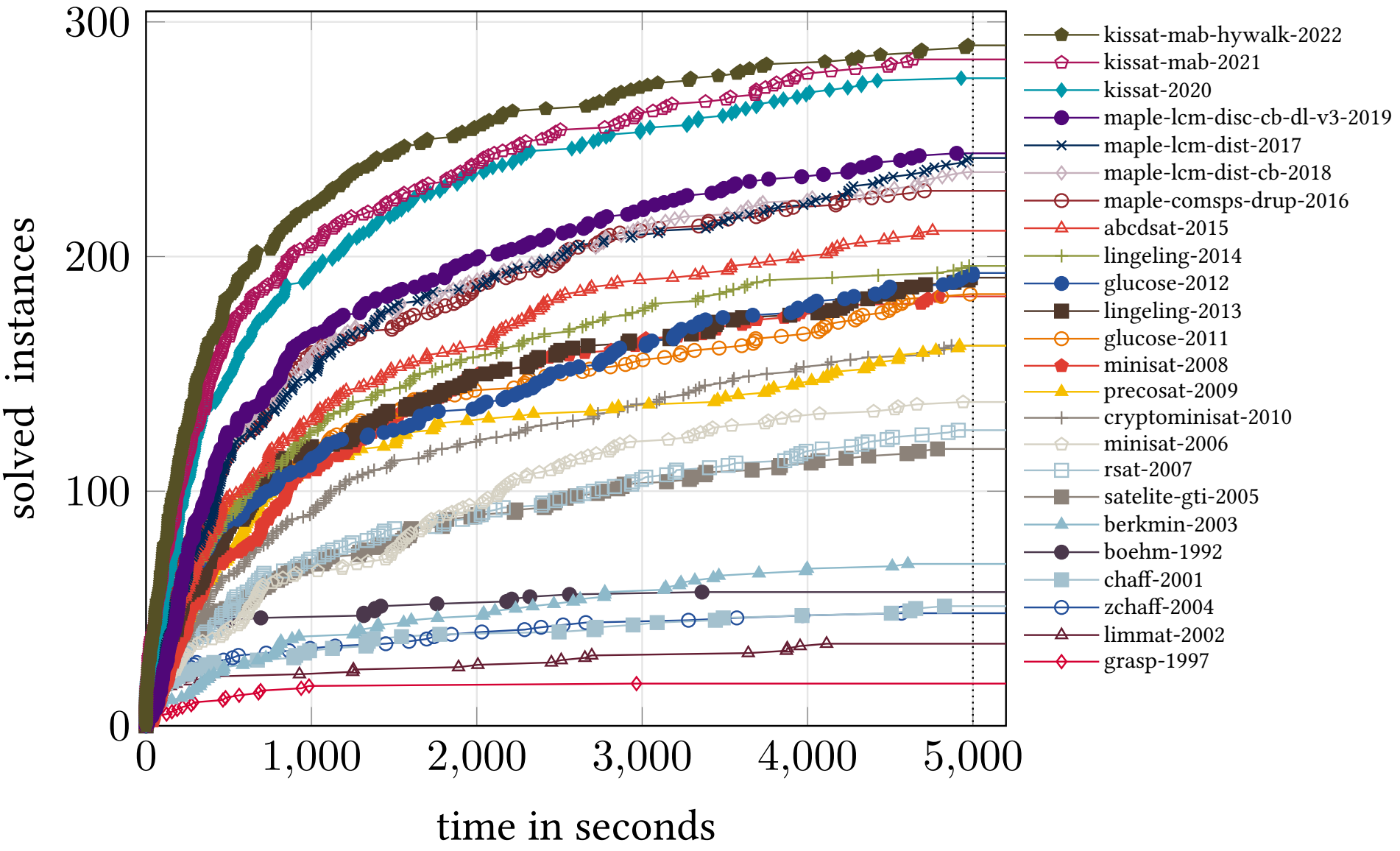

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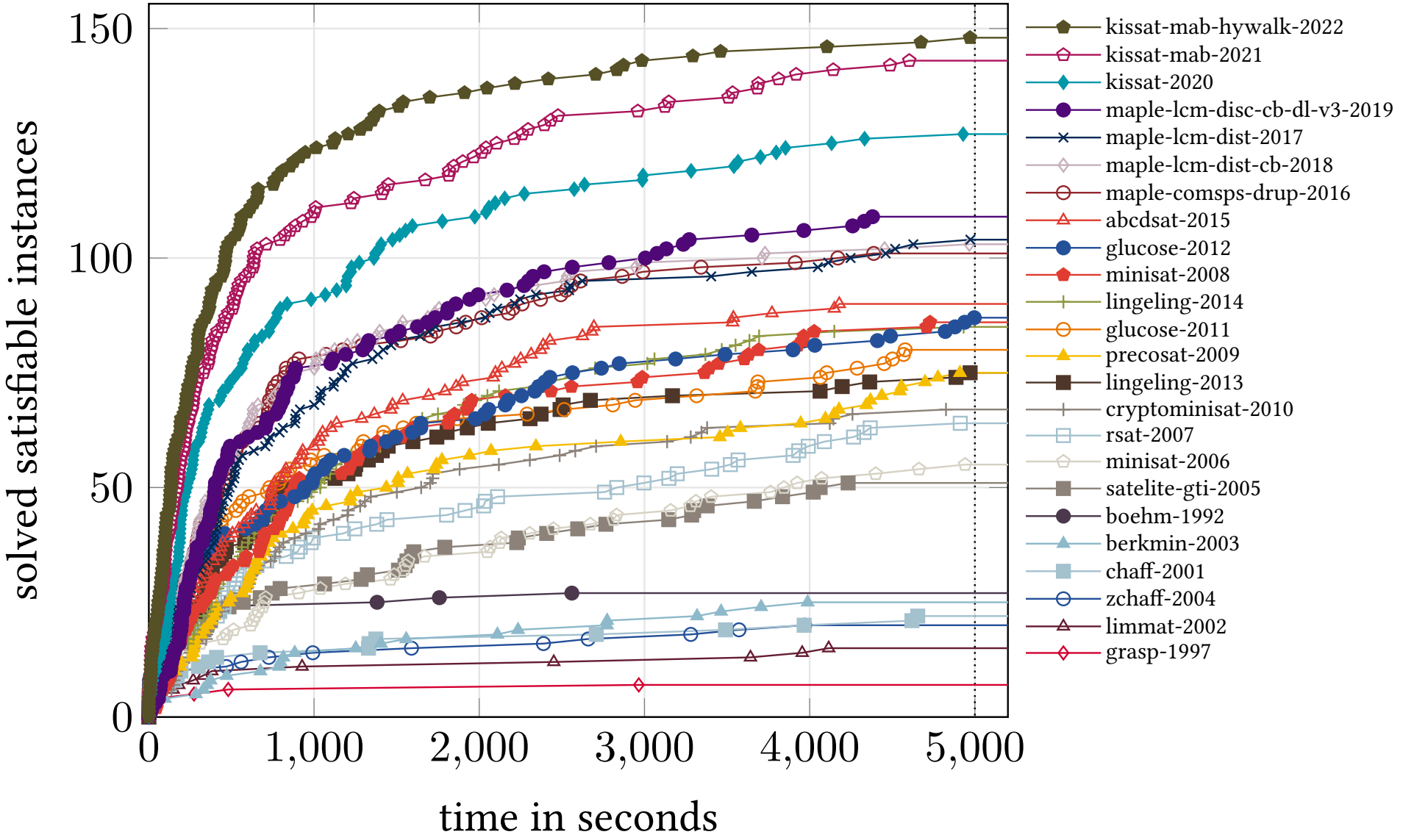

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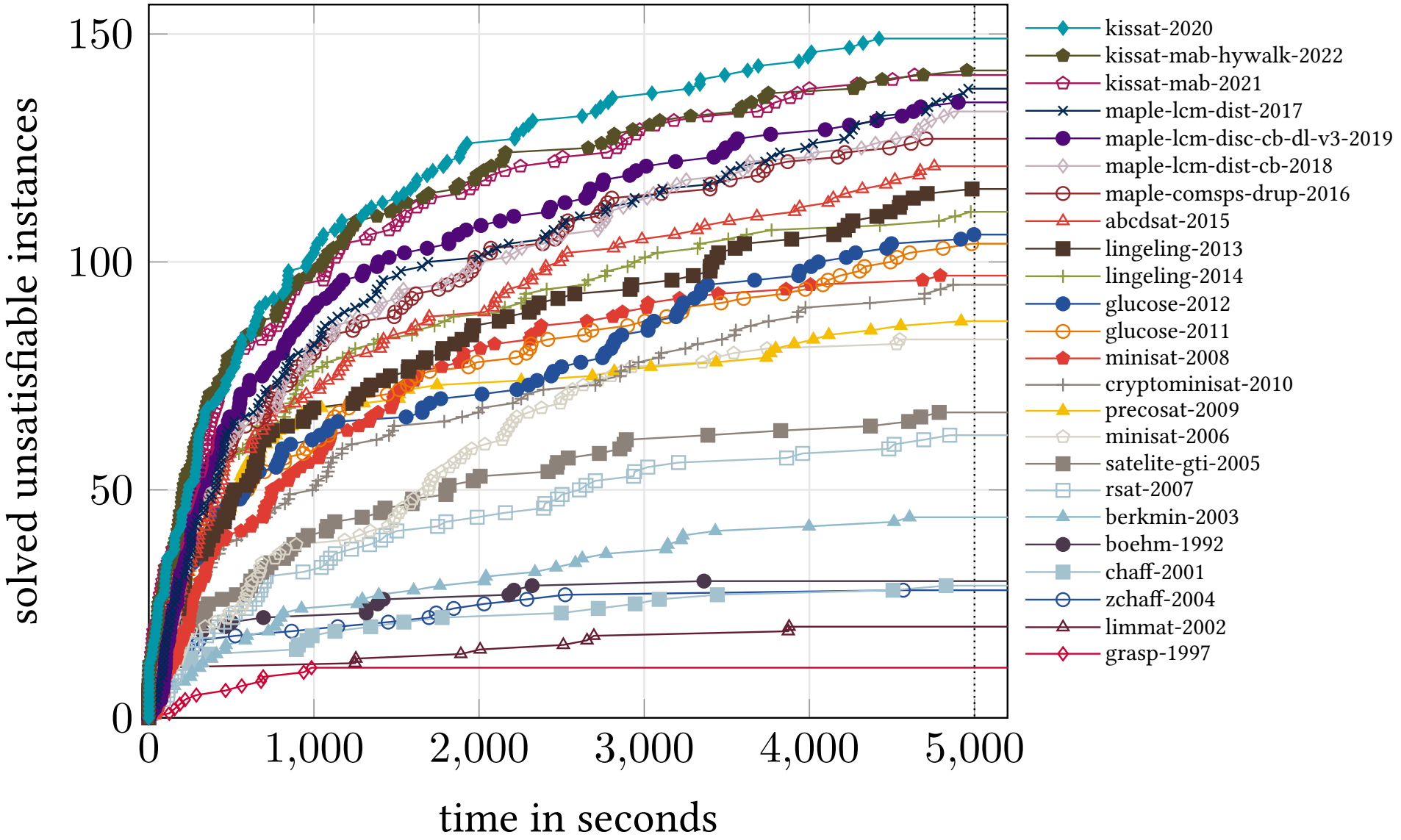

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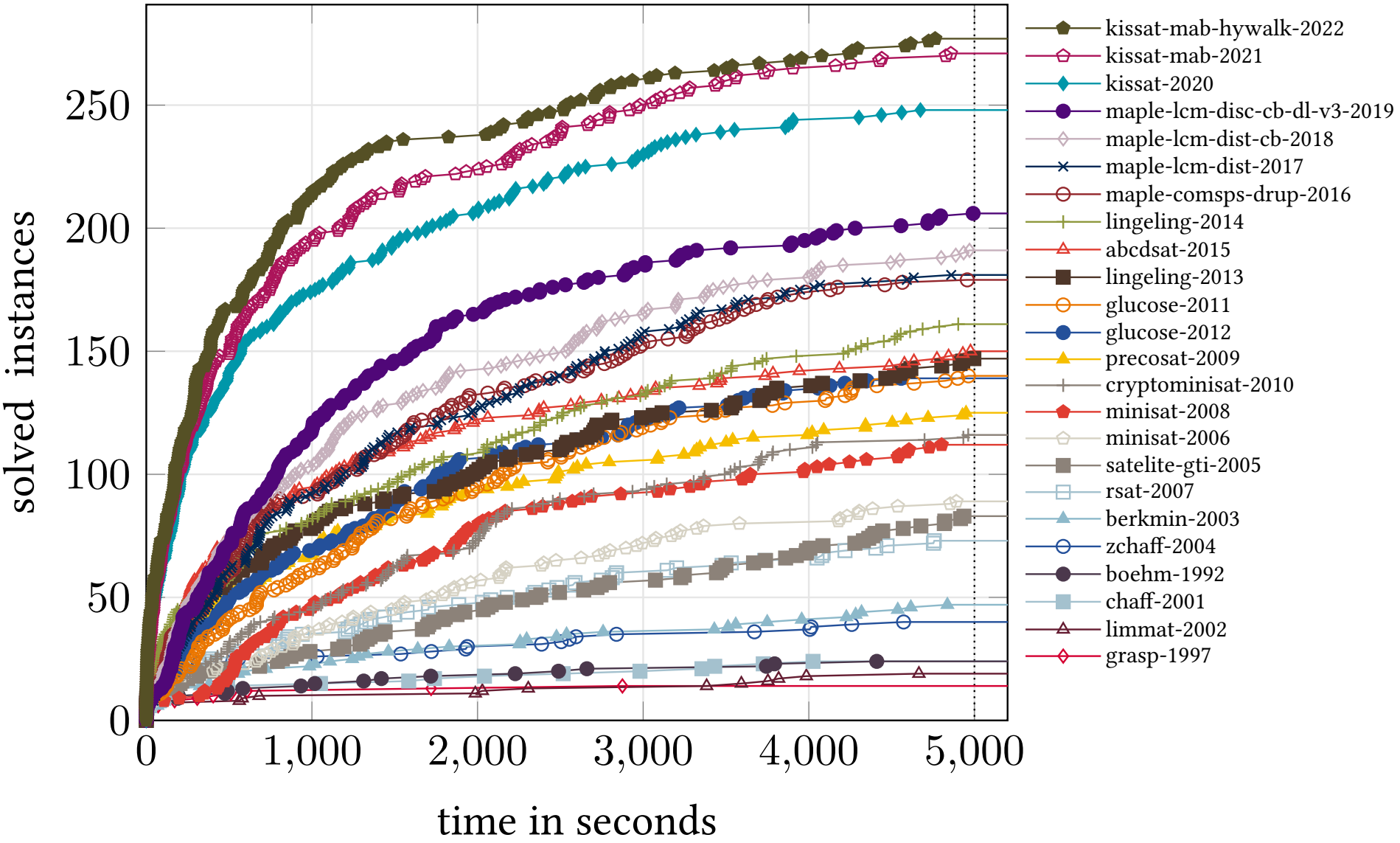

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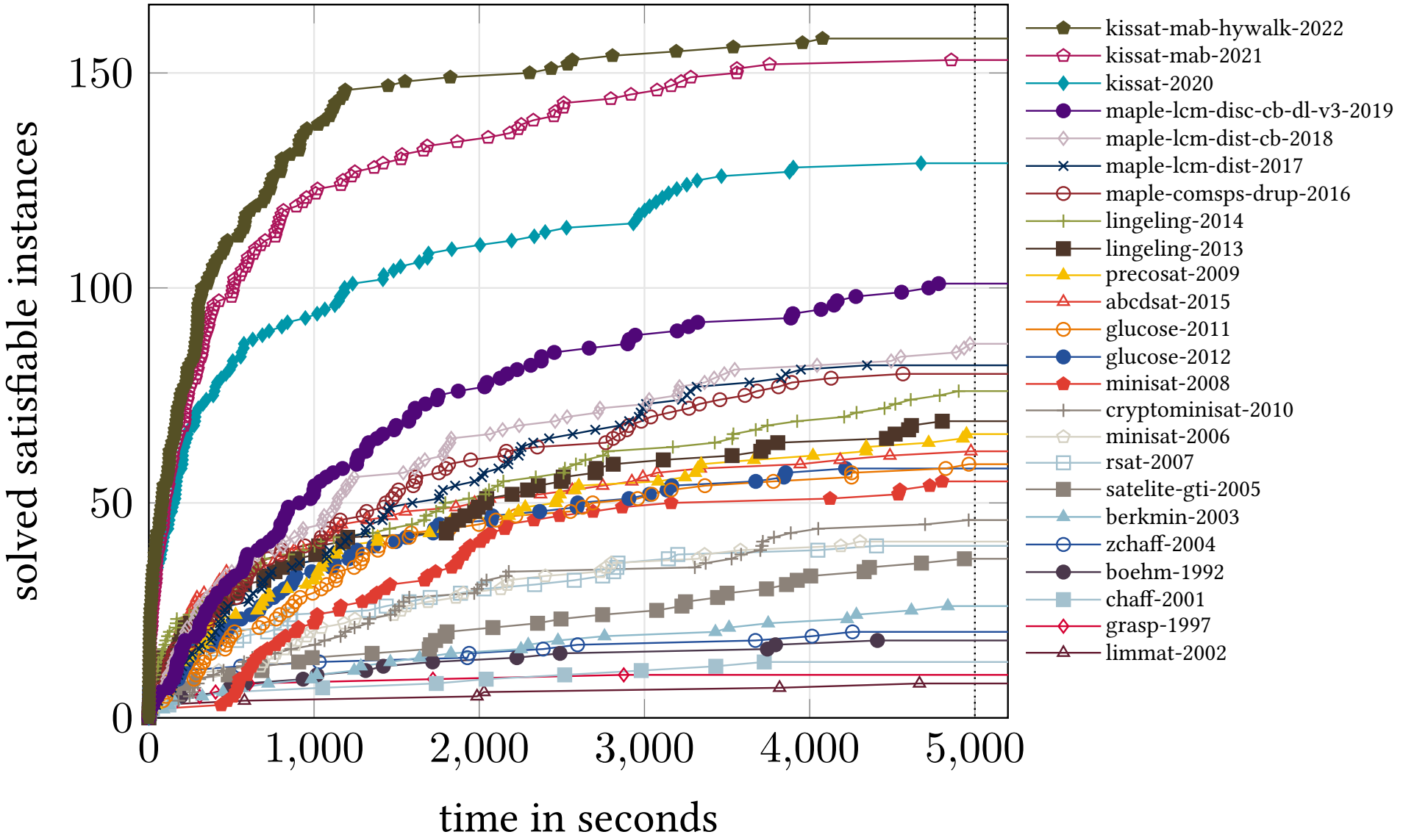

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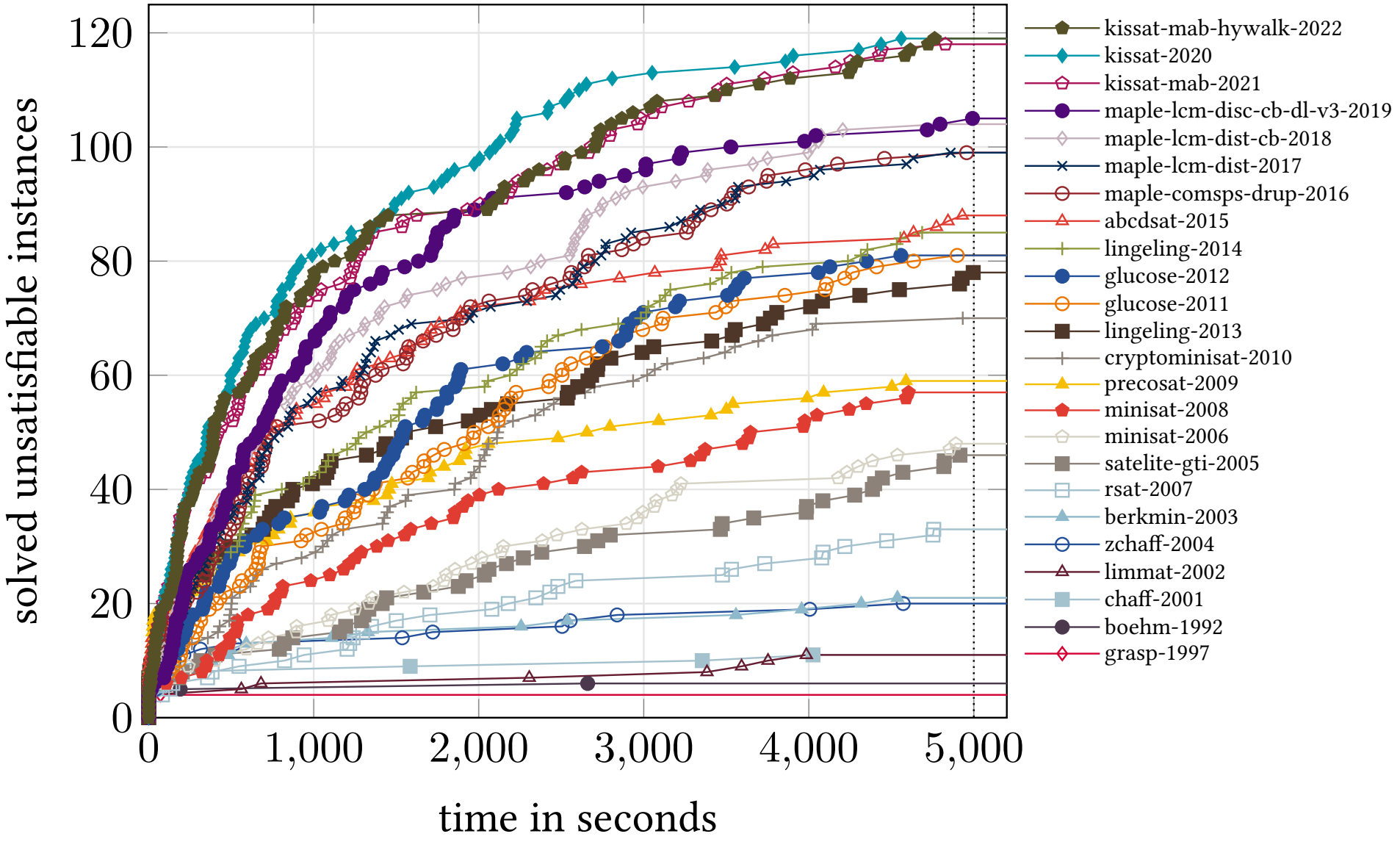

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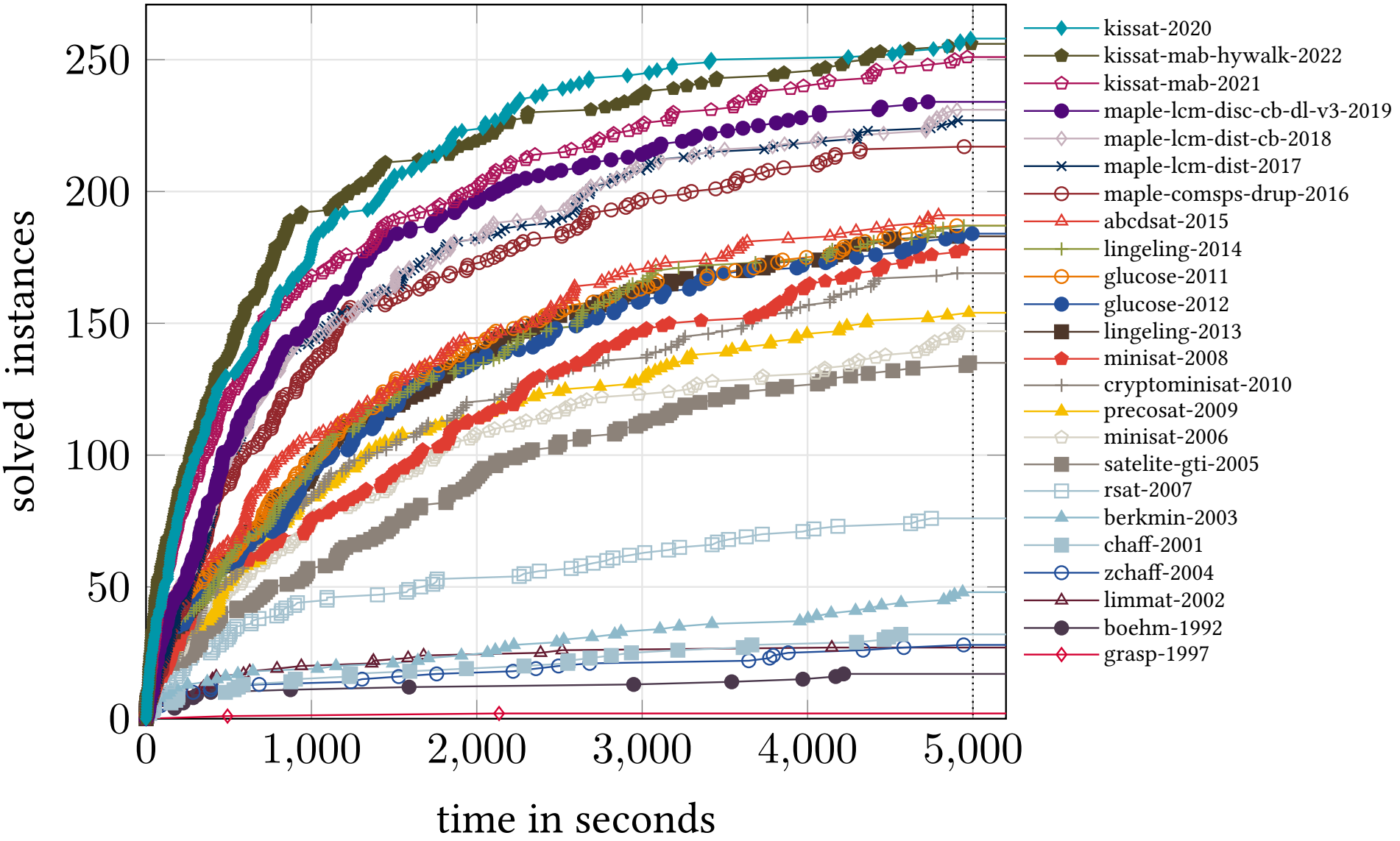

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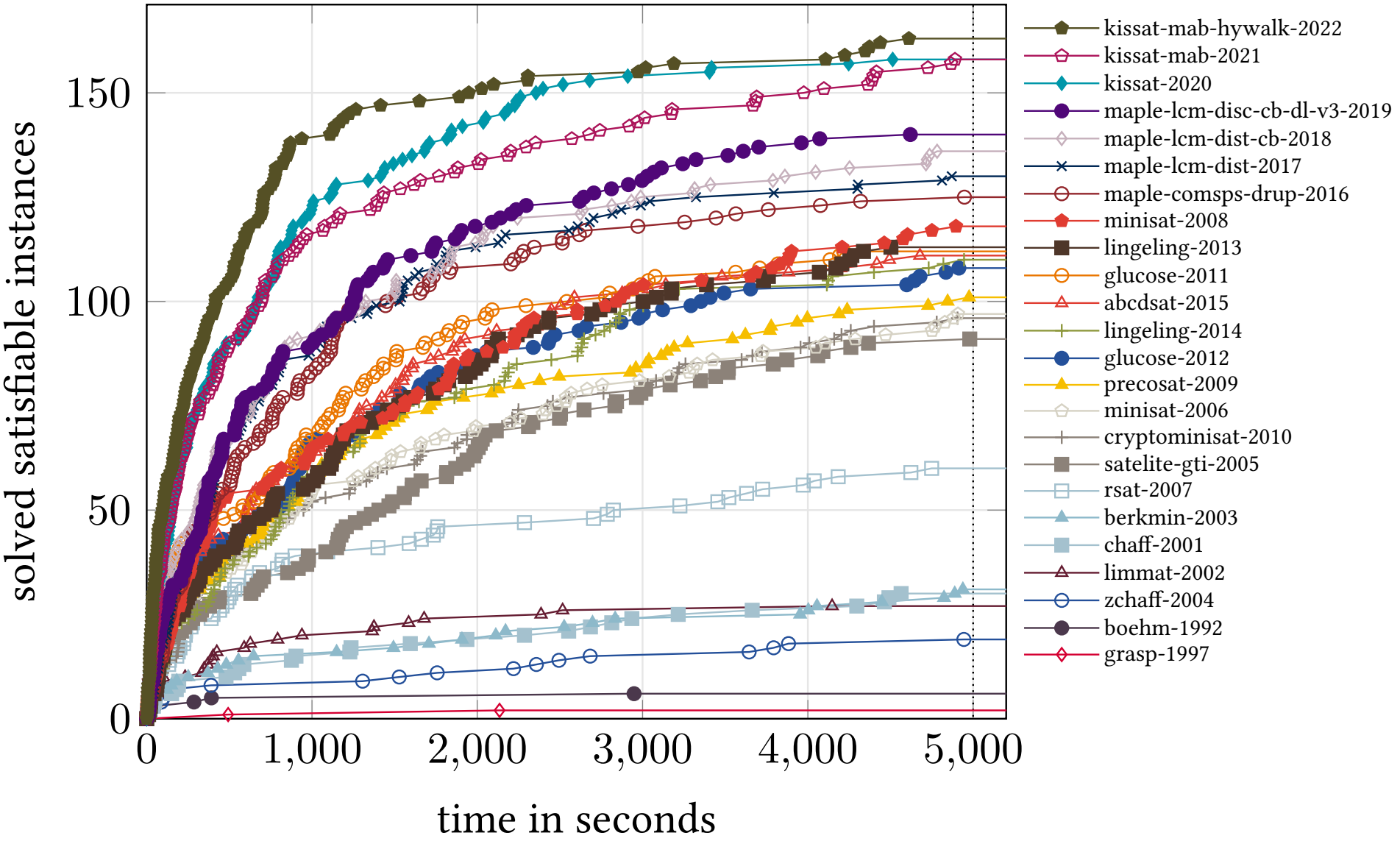

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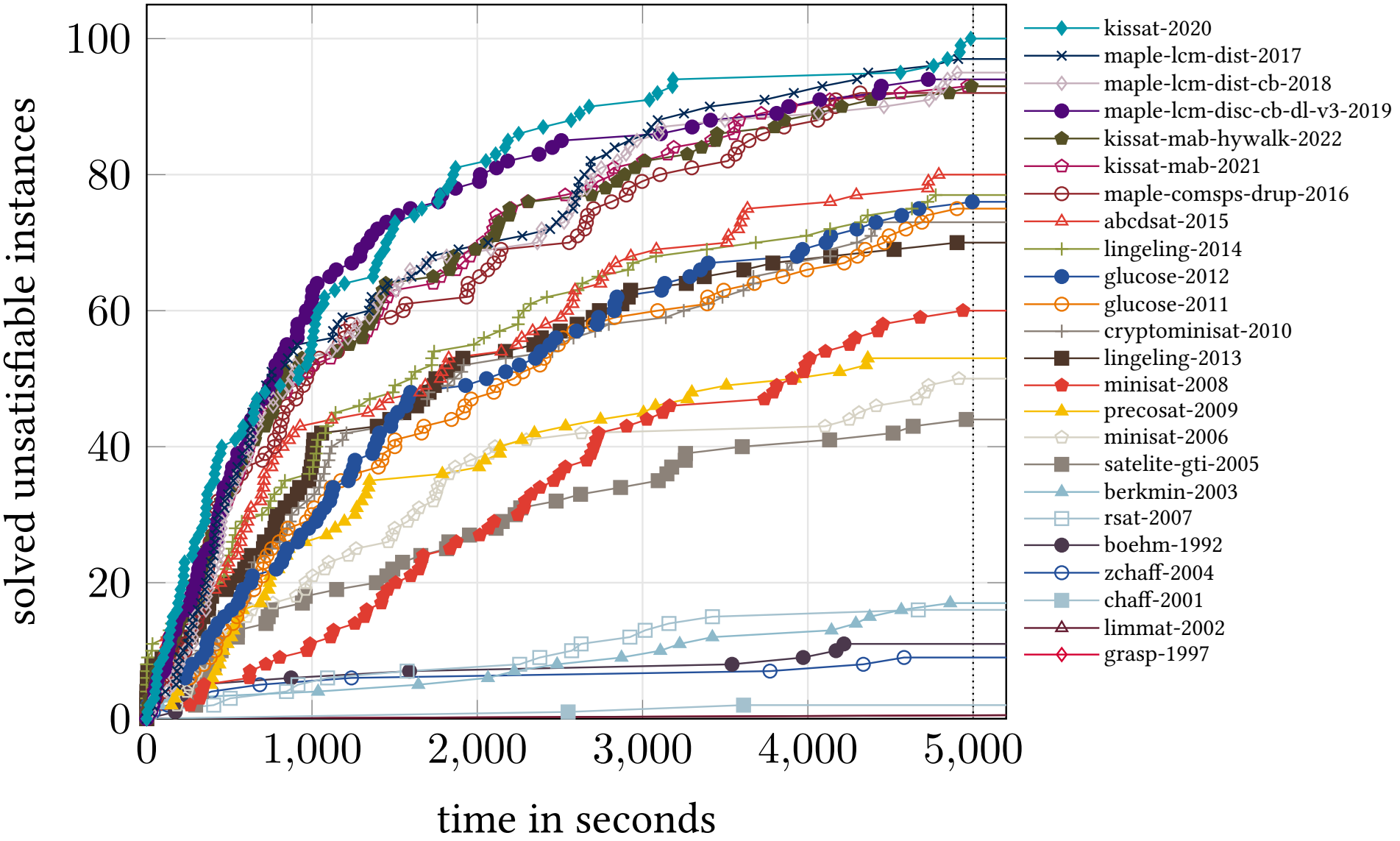

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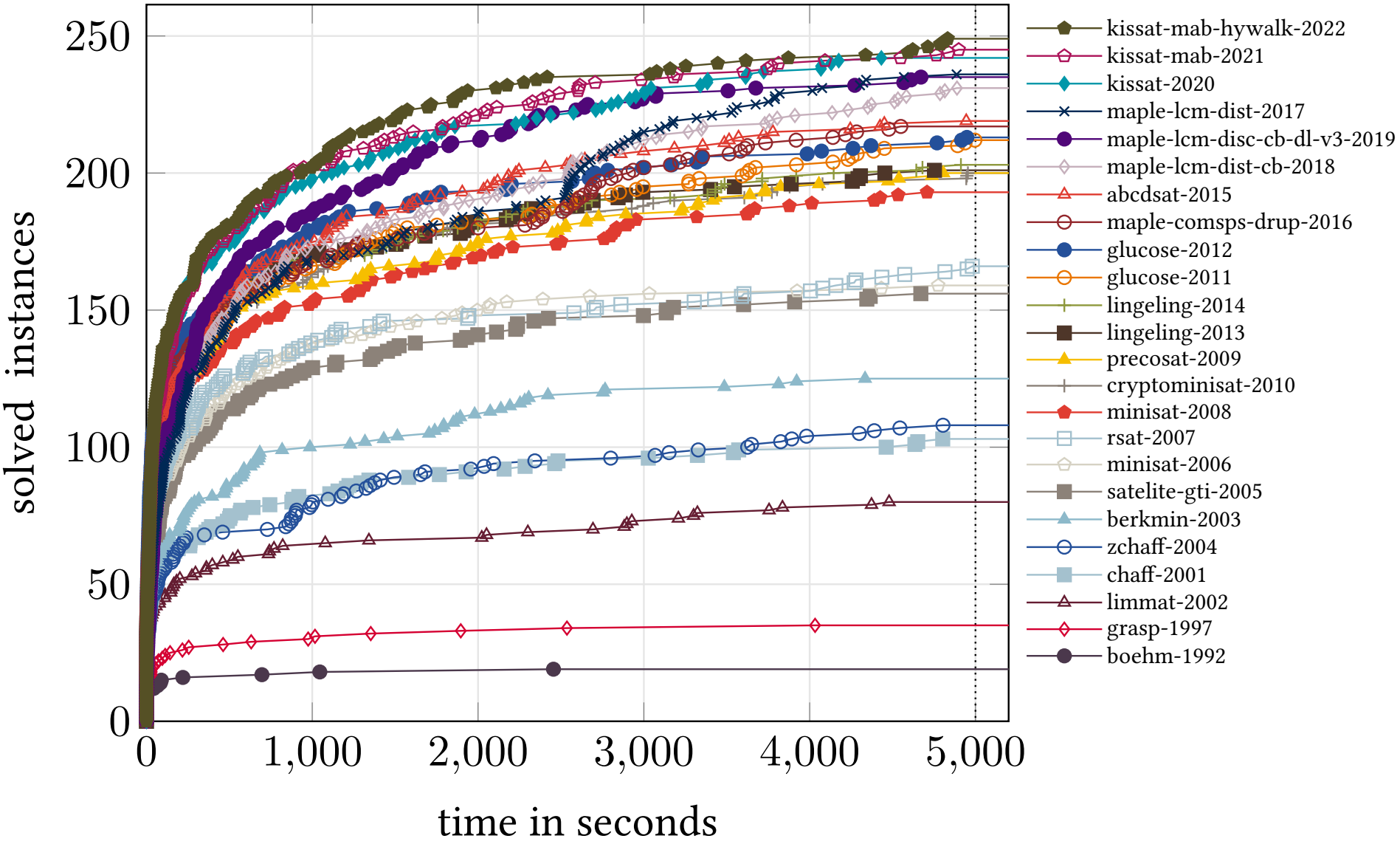

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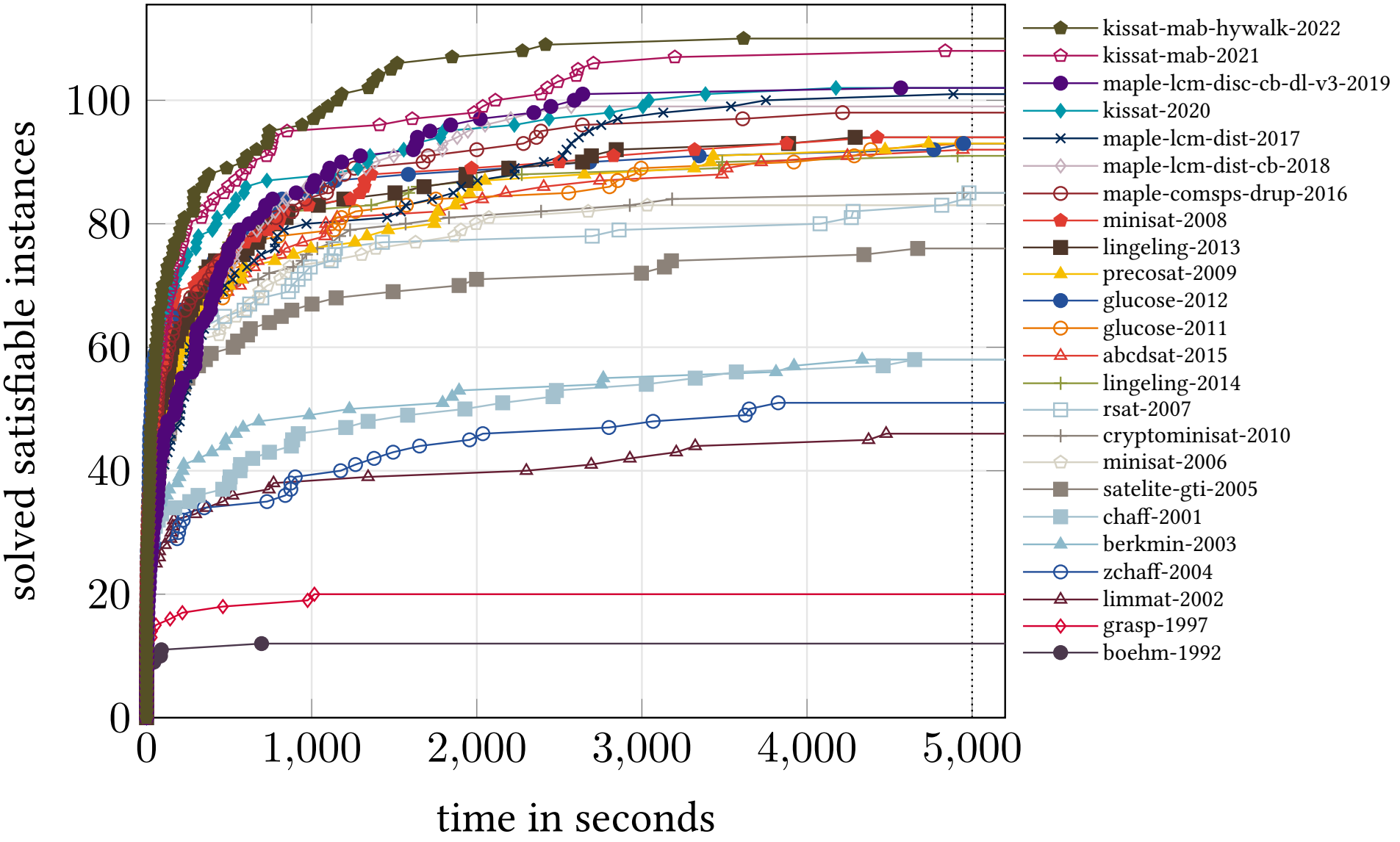

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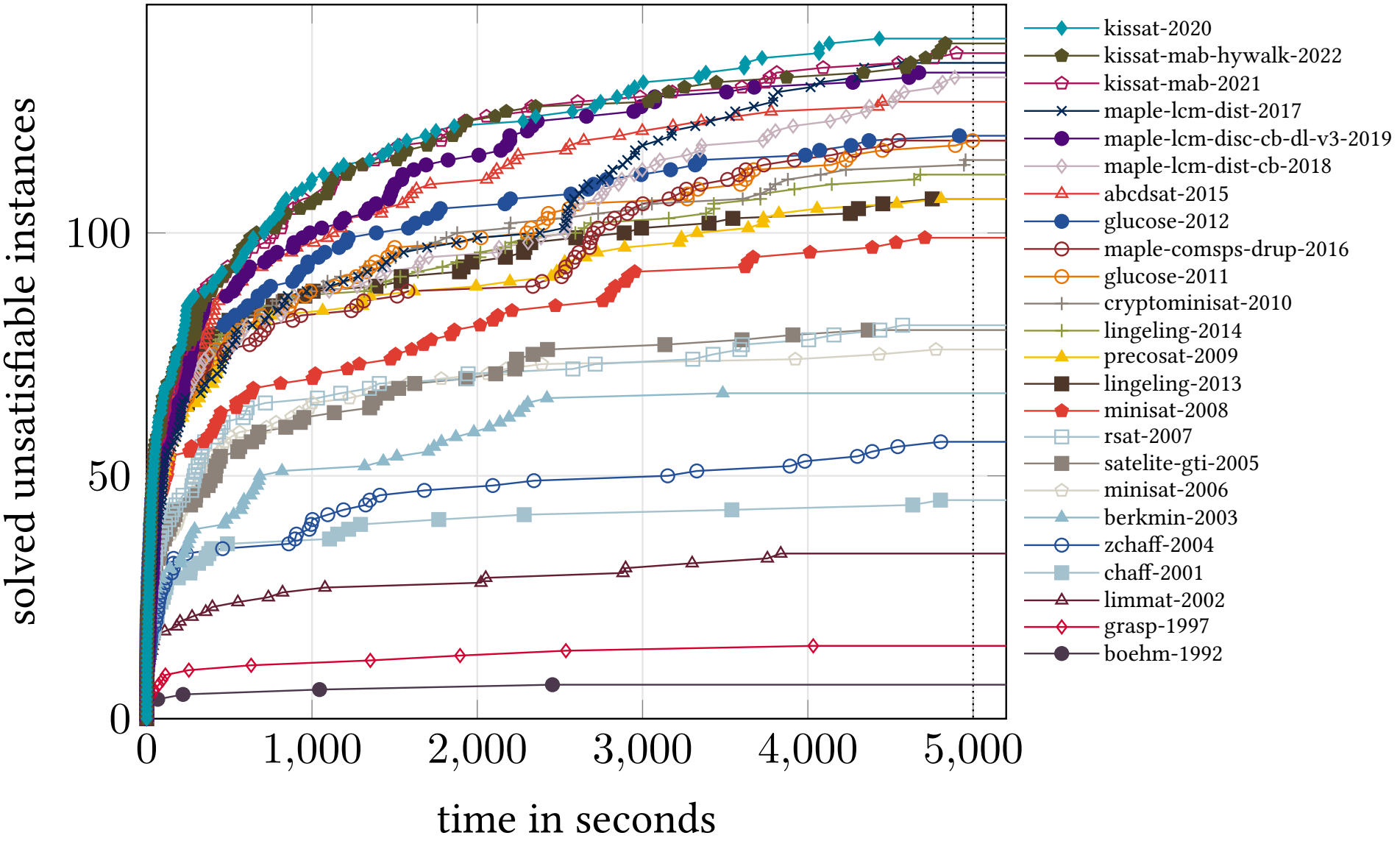

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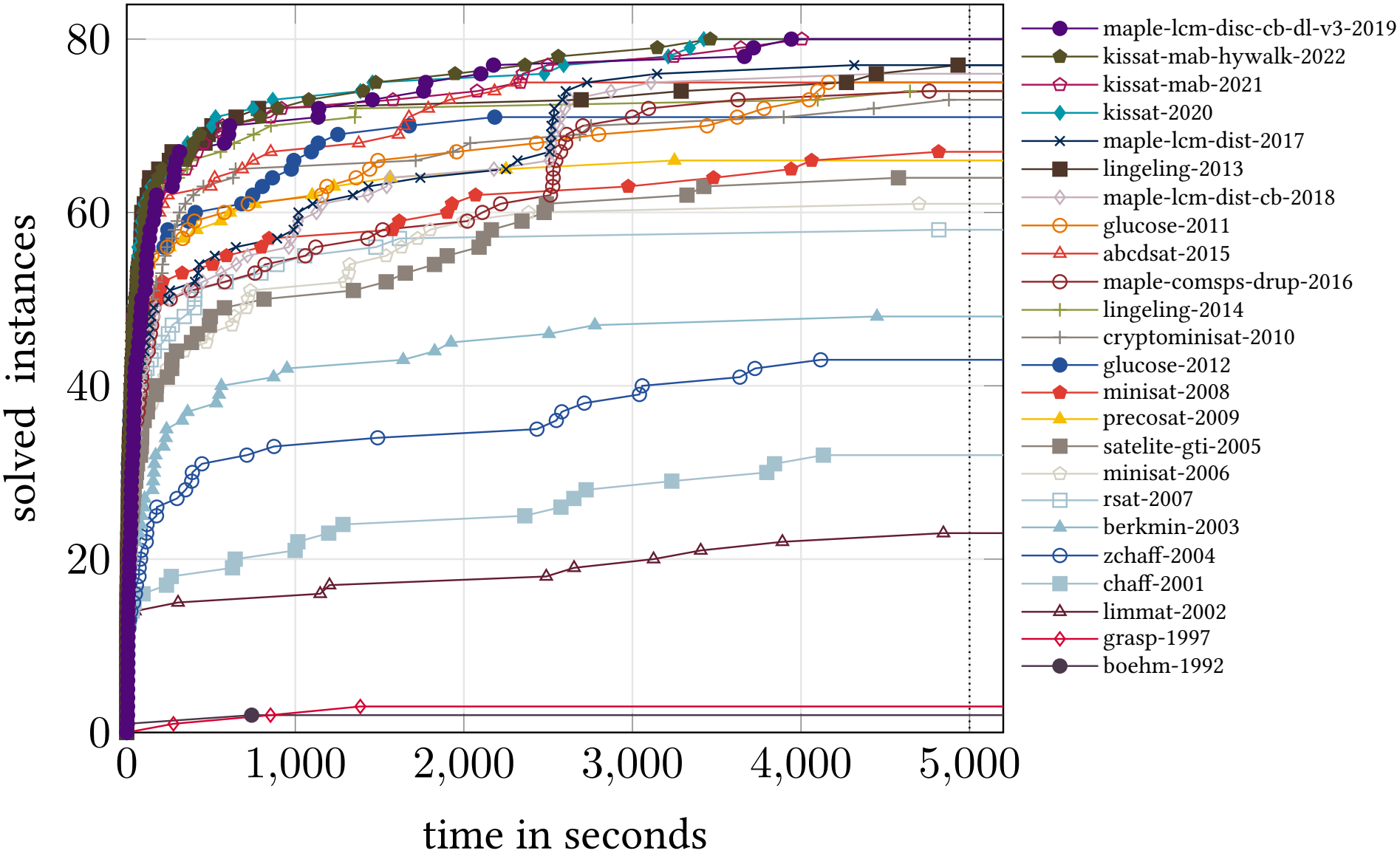

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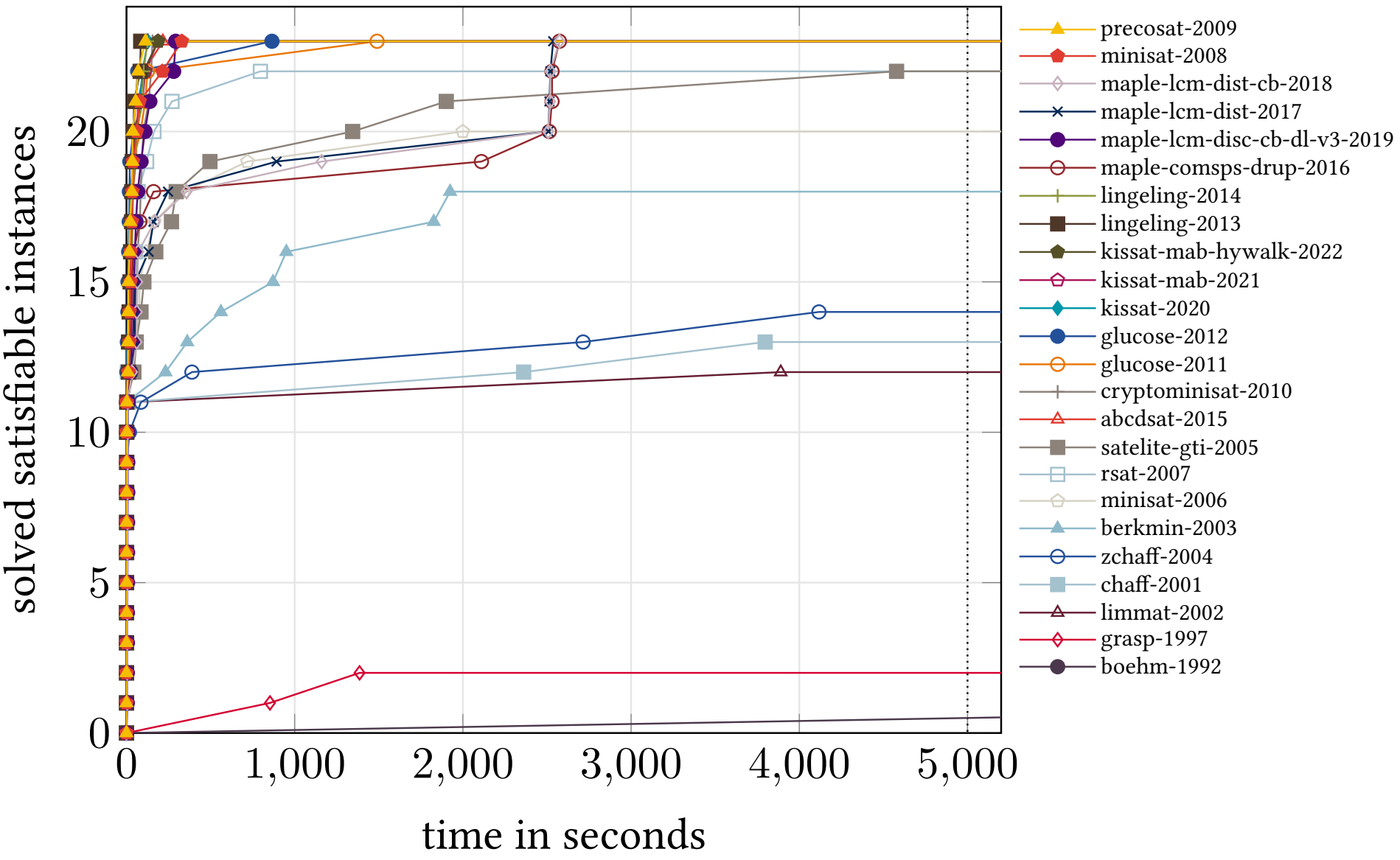
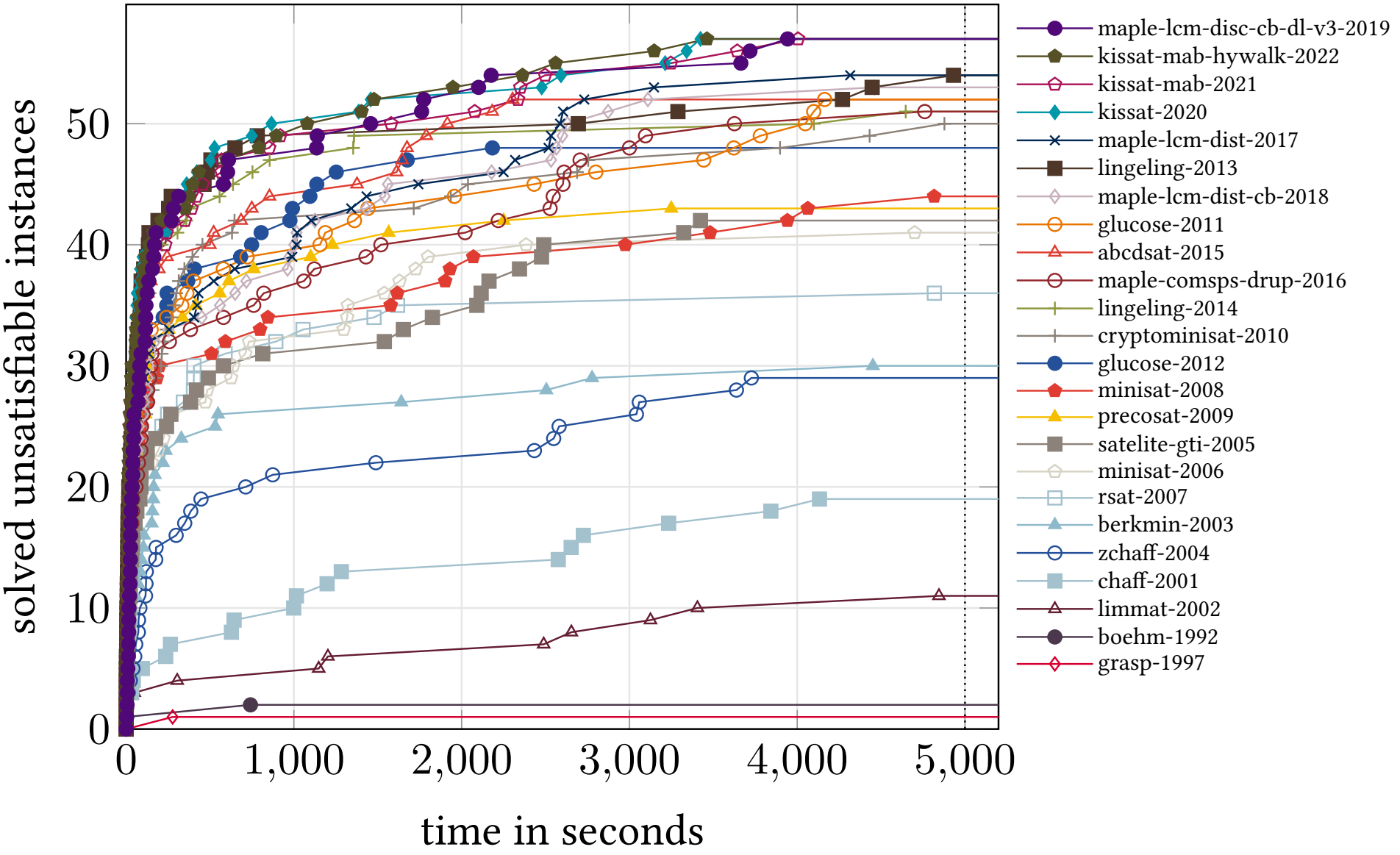
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