

The SAT Museum

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14th International Workshop

Pragmatics of SAT (POS'23)

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affiliated to SAT'23

Goal

It has been stated that

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

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”

Motivation

- assess progress of SAT solving in the last decades
- 24 all-time-winners of 7 SAT Competitions (1992, 2002 - 2022)
 - 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 6 years: 2002, 2011, 2019, 2020, 2021, 2022
 - again only application / main track
 - not merged so compared separately per year
no need to remove duplicates
- collect and patch solvers

Solvers Features - 1st Decade

■ Before Preprocessing

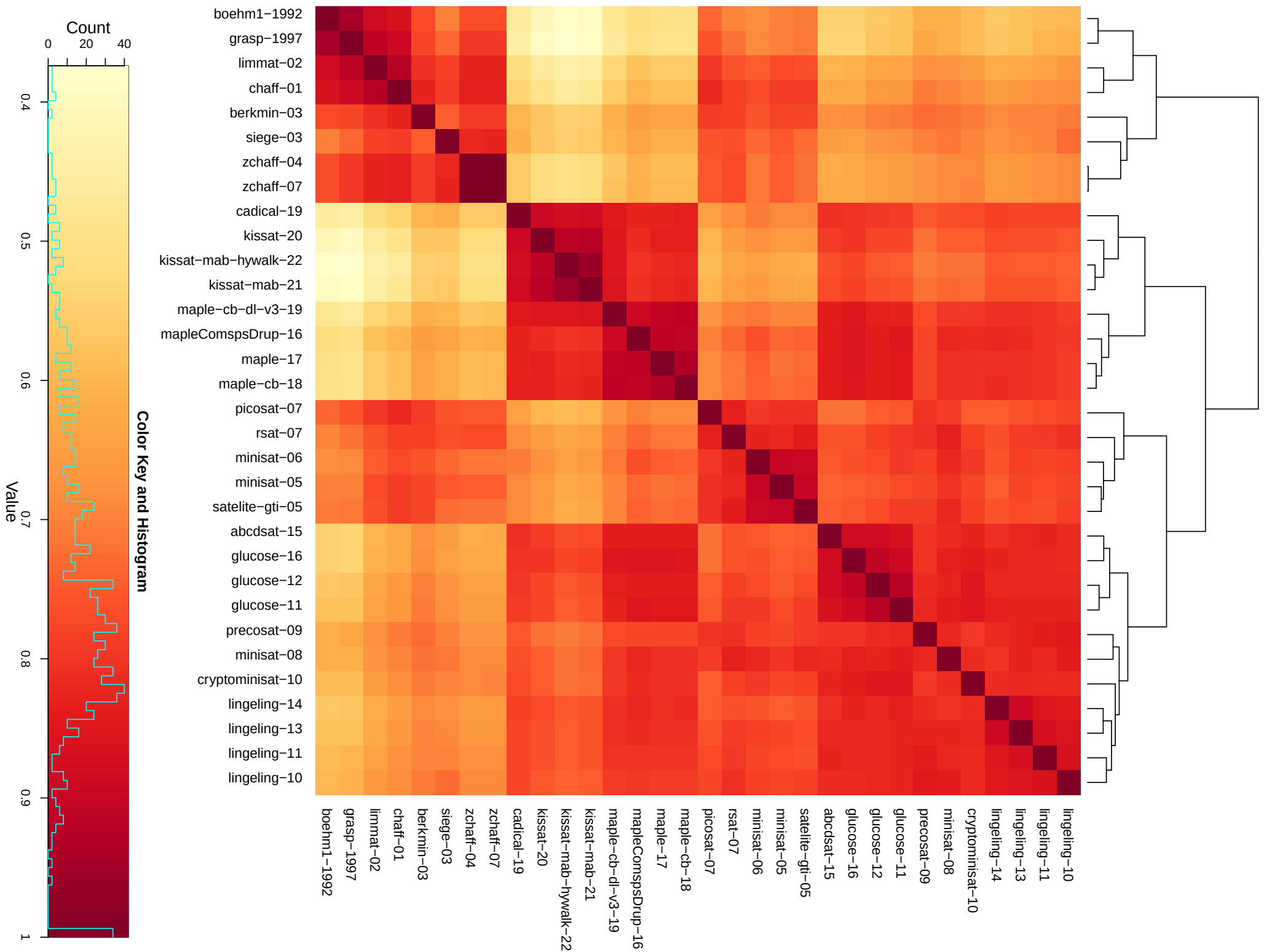
- DPLL solver boehm1-1992
- seminal CDCL solvers grasp-1997, chaff-2001, zchaff-200[147]
- (almost) winners limmat-2002, siege-2003 (vmtf), berkmin-2003
- SAT'22 test-of-time awardee minisat-200[5678] incl. minimization
note however that the MiniSat paper is from 2003

■ 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)



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
 - 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

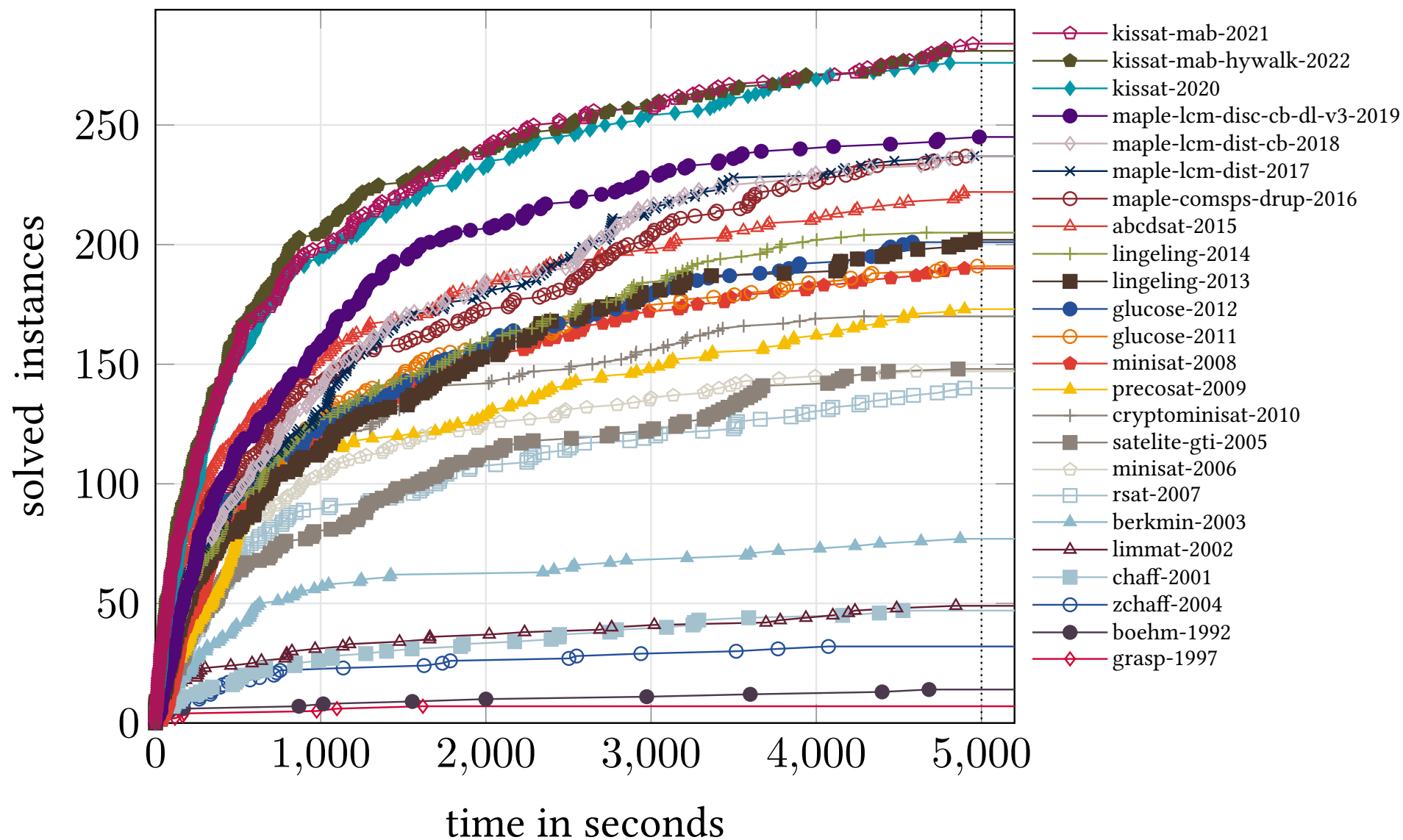
■ Hardware

- 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)

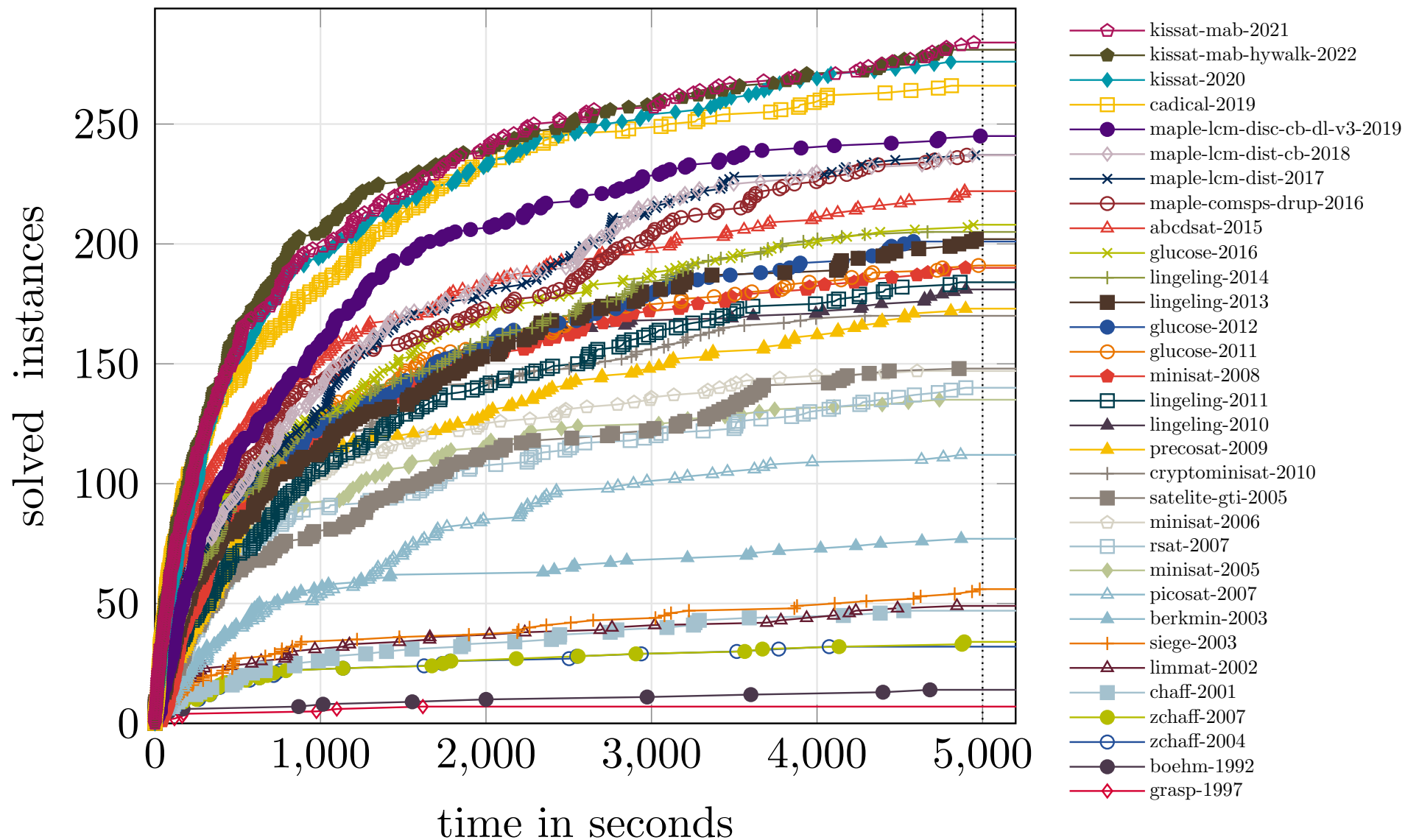
■ Software

- 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



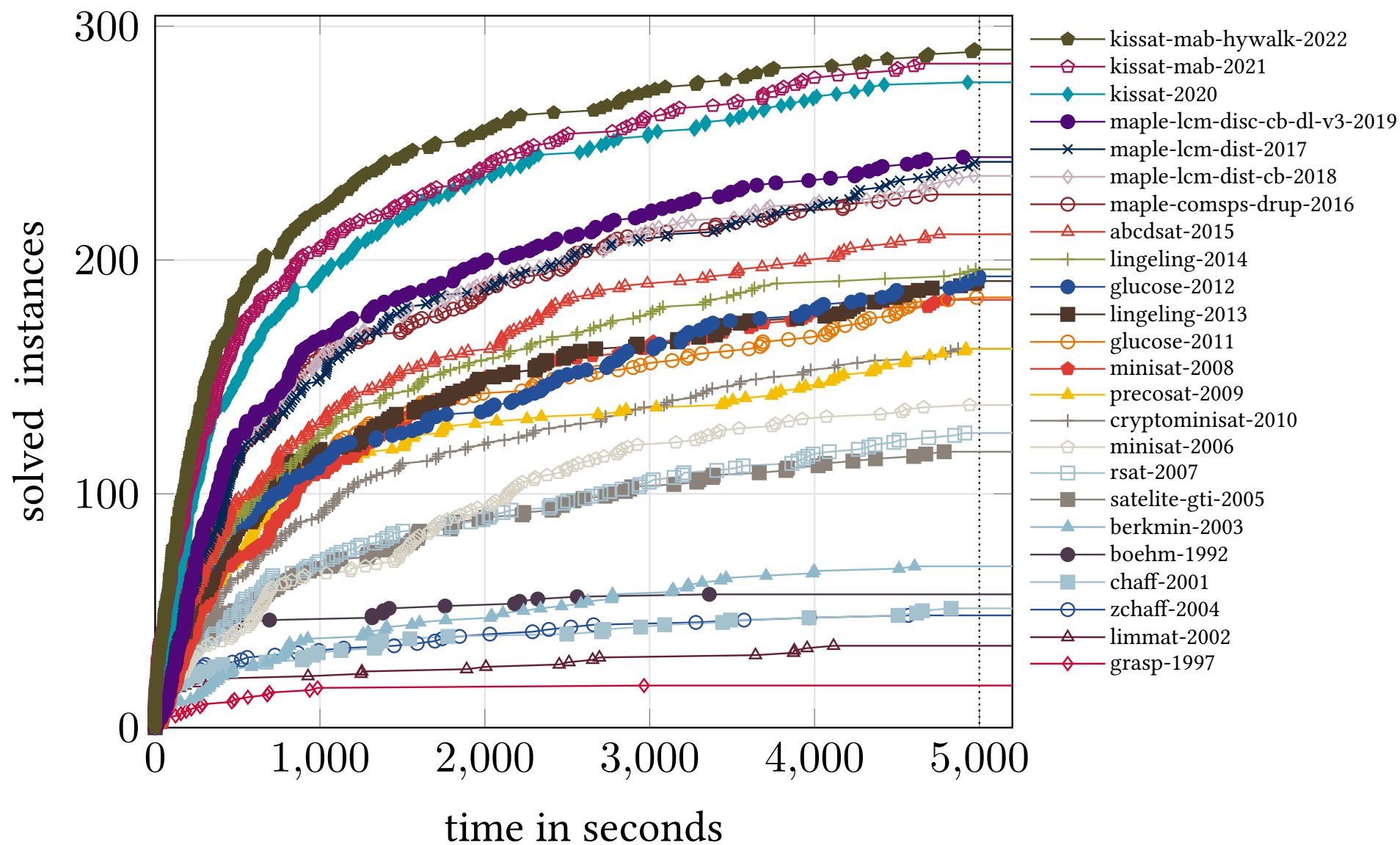
Winners & Legacy Solvers — SAT Competition 2022 — Solved



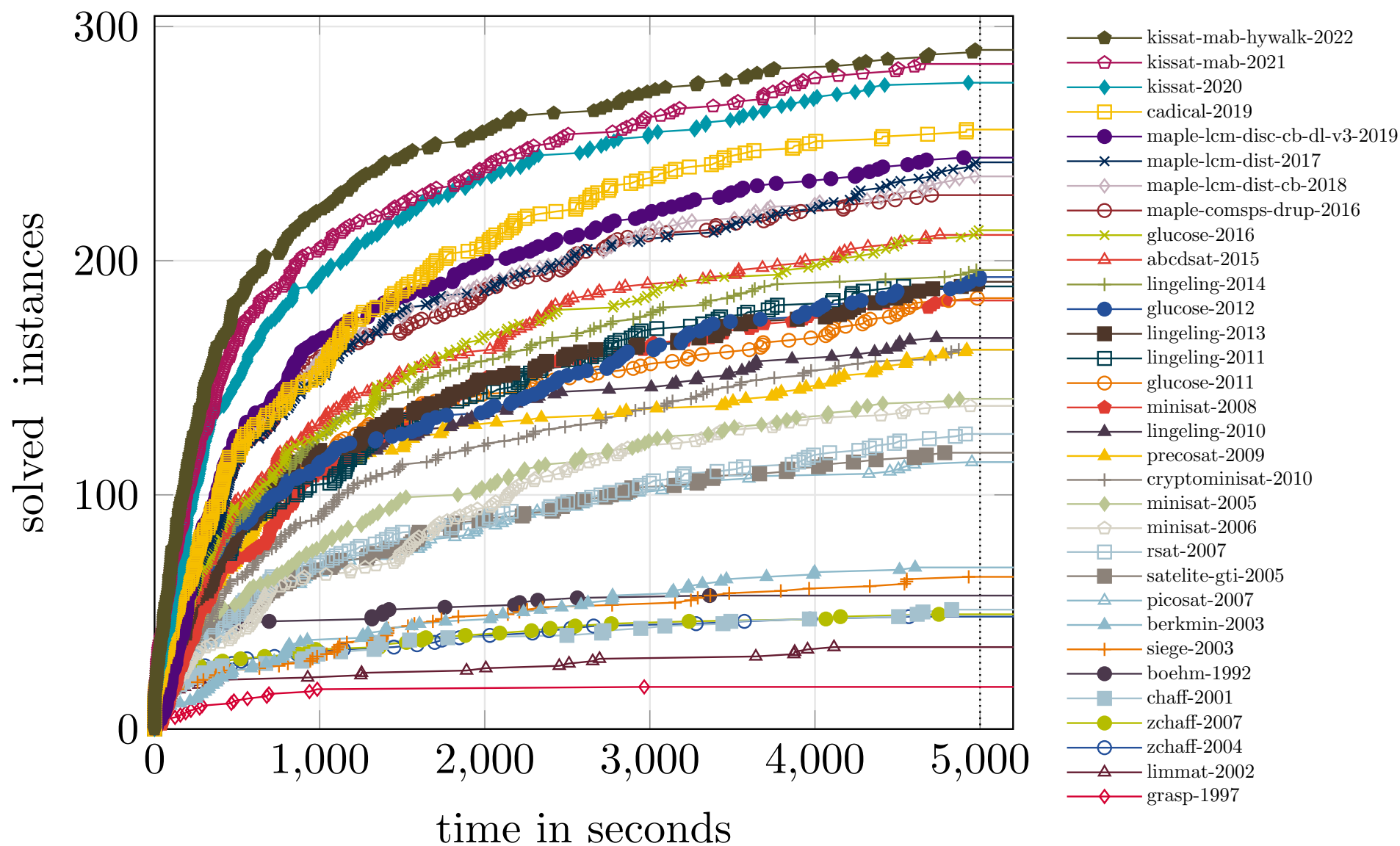
Winners & Legacy Solvers — SAT Competition 2022

	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
	abcsat-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



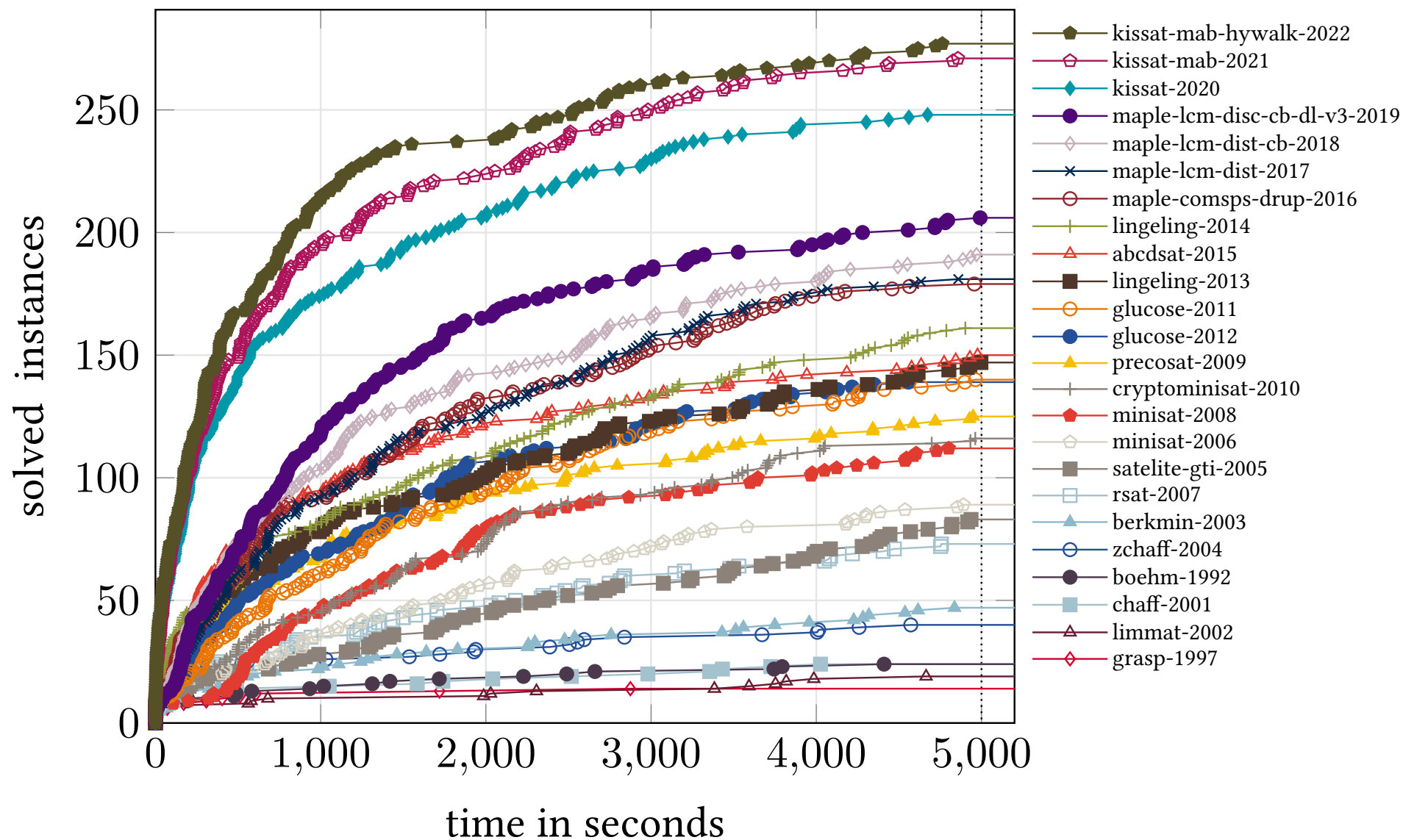
Winners & Legacy Solvers — SAT Competition 2021



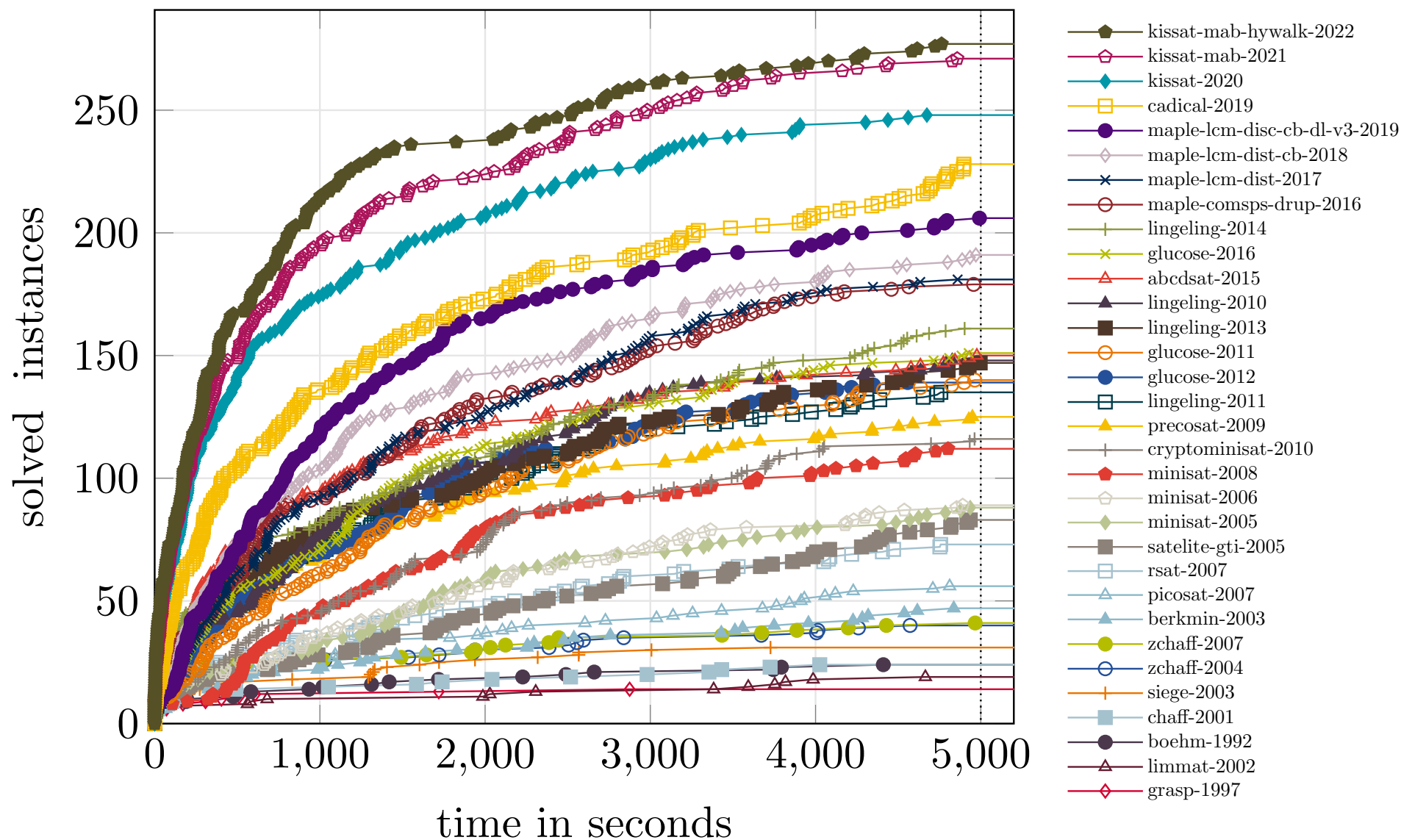
Winners & Legacy Solvers — SAT Competition 2021

	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
	abcsat-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



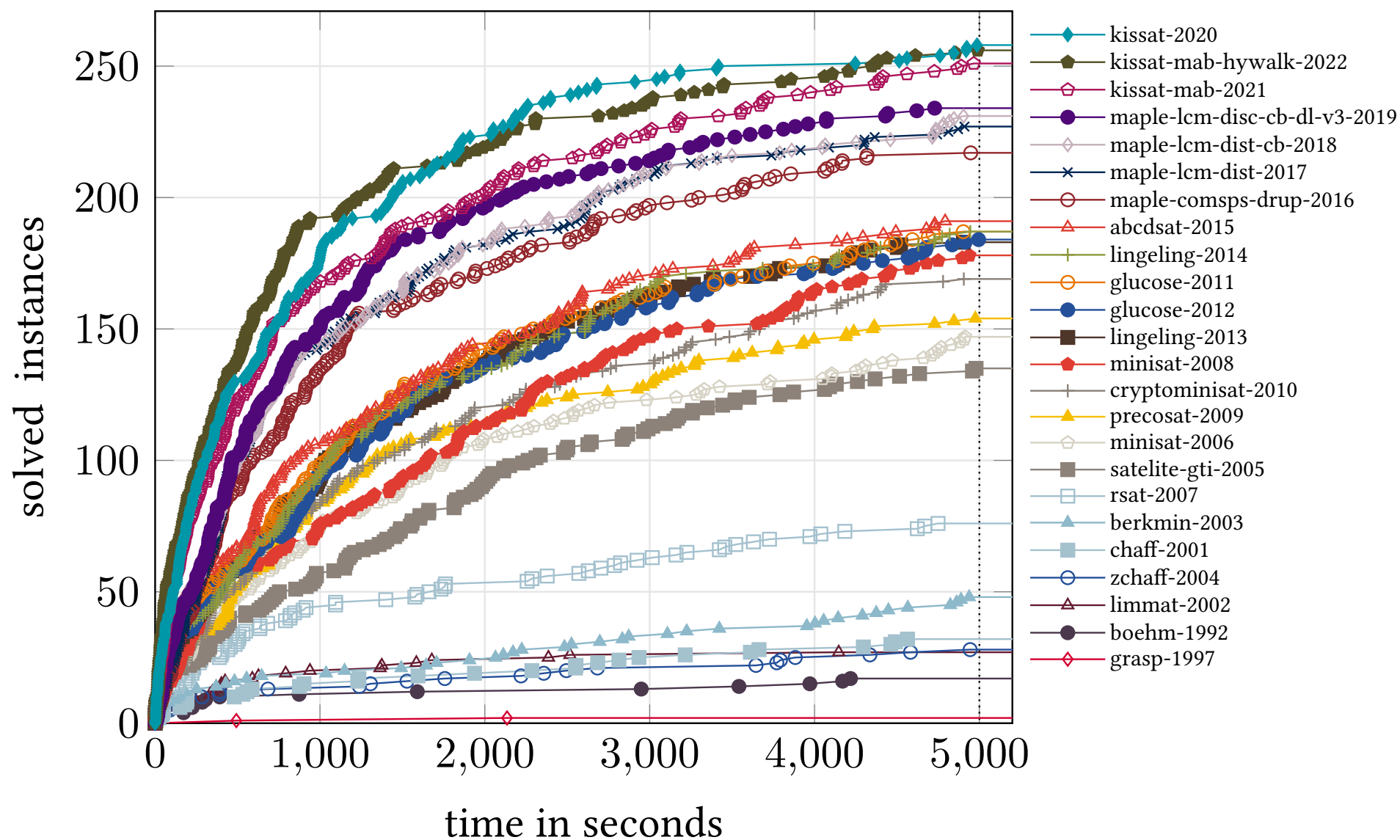
Winners & Legacy Solvers — SAT Competition 2020



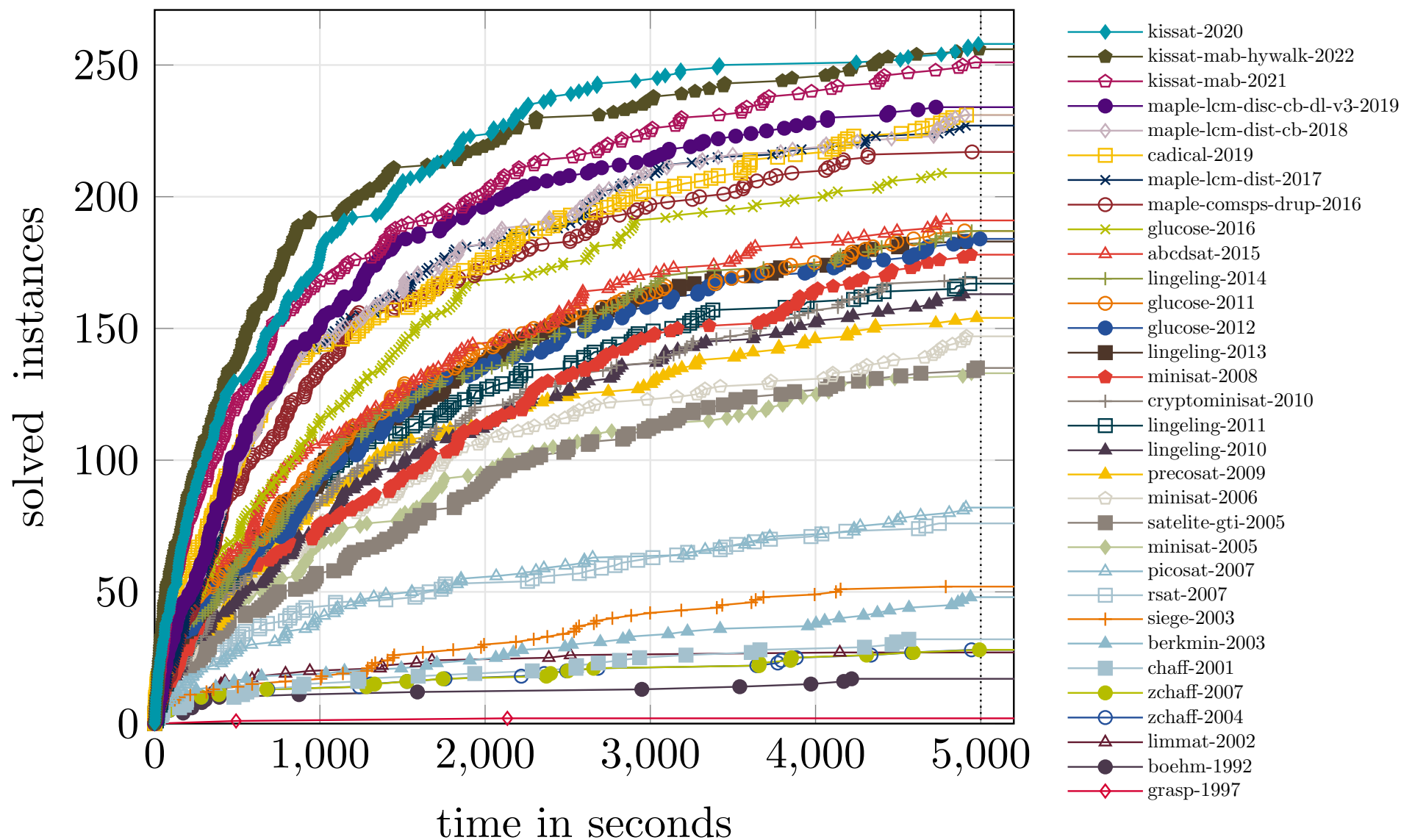
Winners & Legacy Solvers — SAT Competition 2020

	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
	abcsat-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



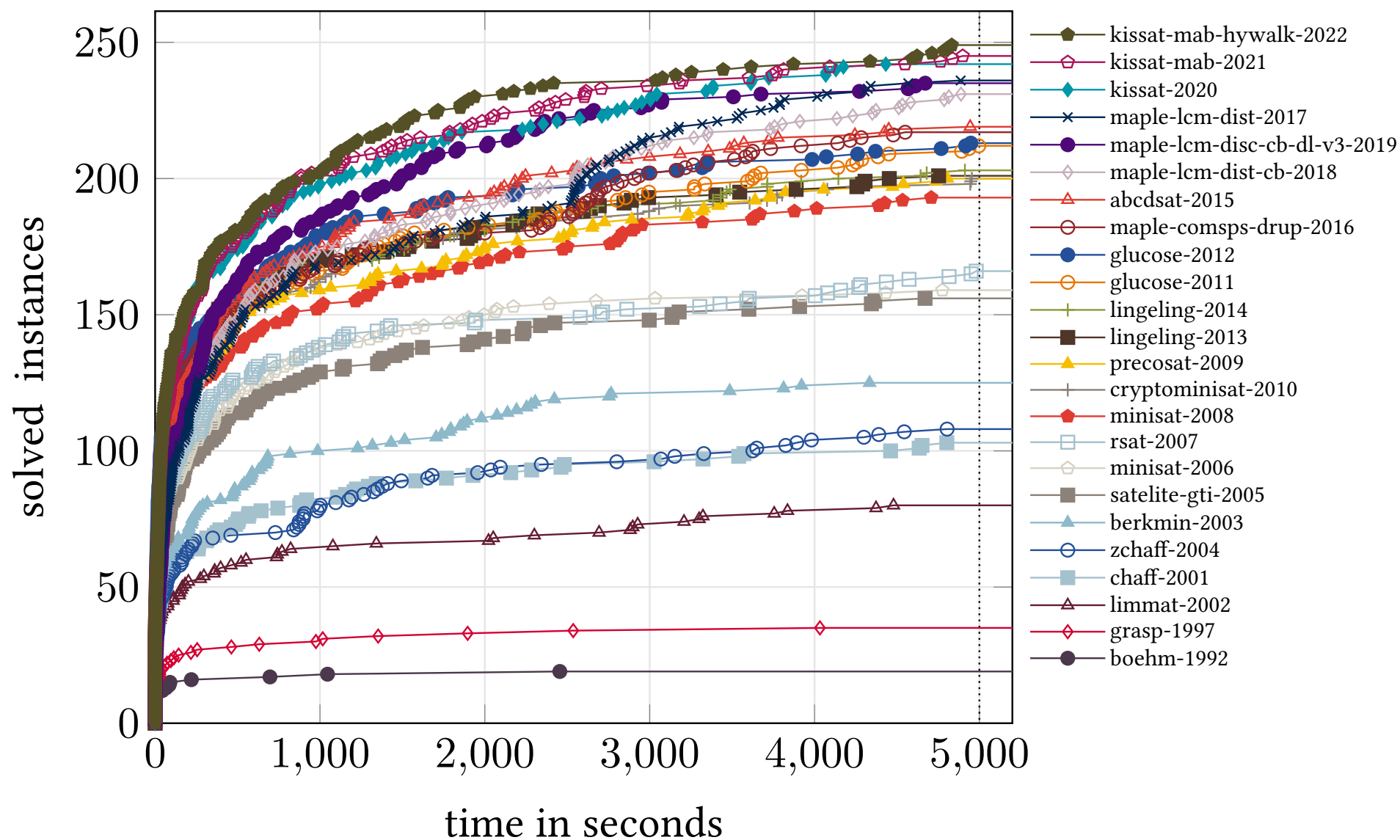
Winners & Legacy Solvers — SAT Competition 2019



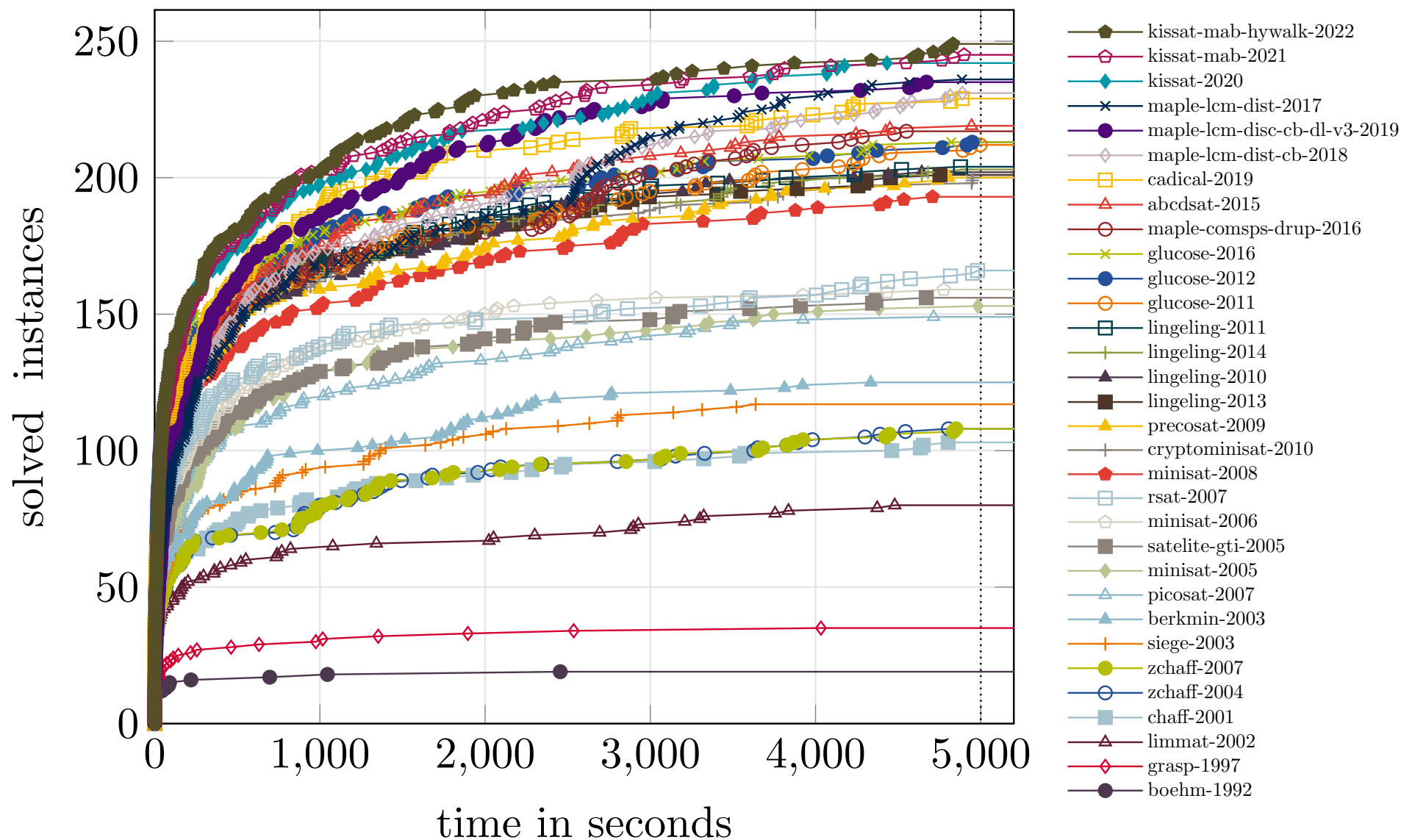
Winners & Legacy Solvers — SAT Competition 2019

	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



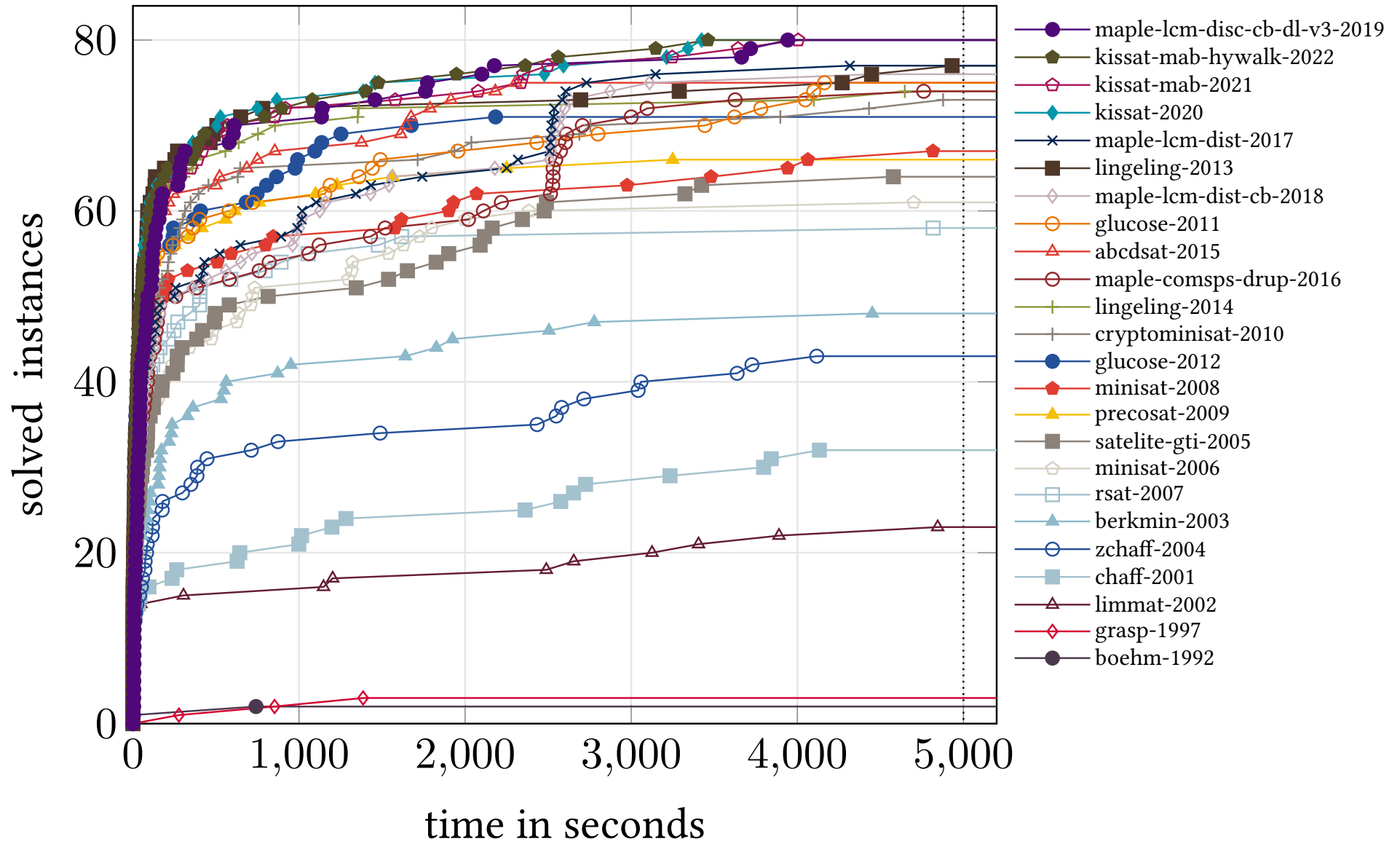
Winners & Legacy Solvers — SAT Competition 2011



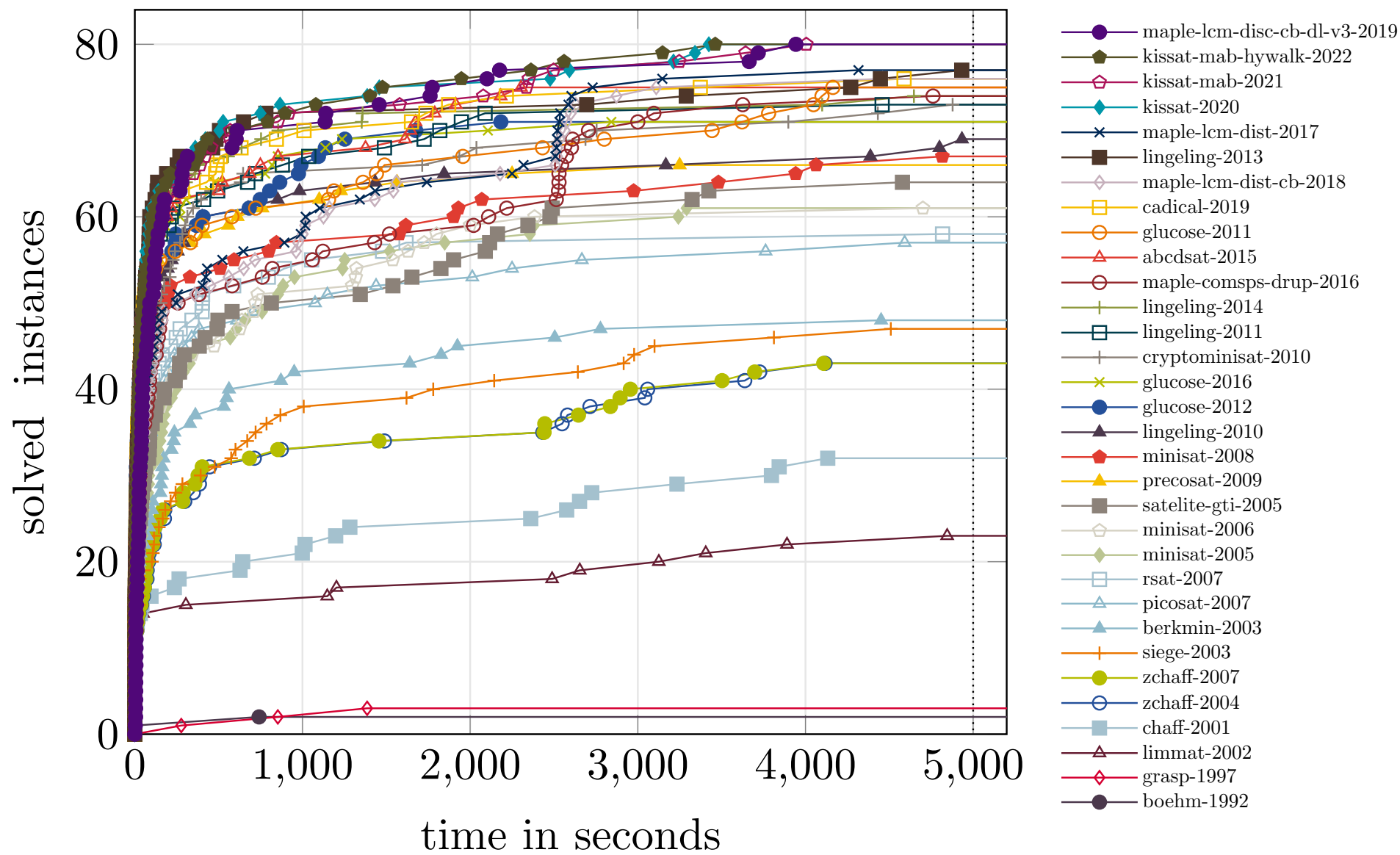
Winners & Legacy Solvers — SAT Competition 2011

	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
	abcsat-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
	abcsat-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

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 6 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 6 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.

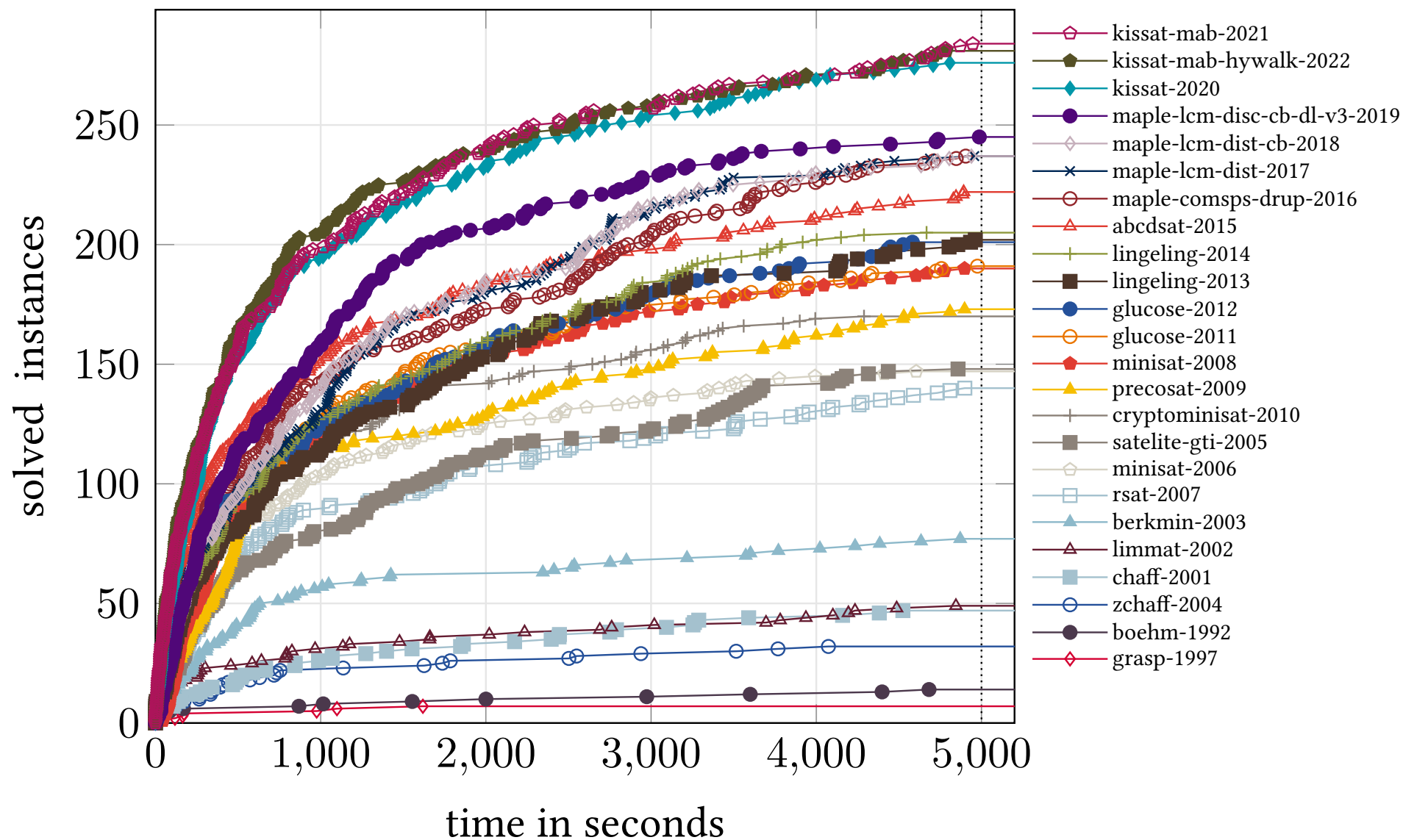
Conclusion

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

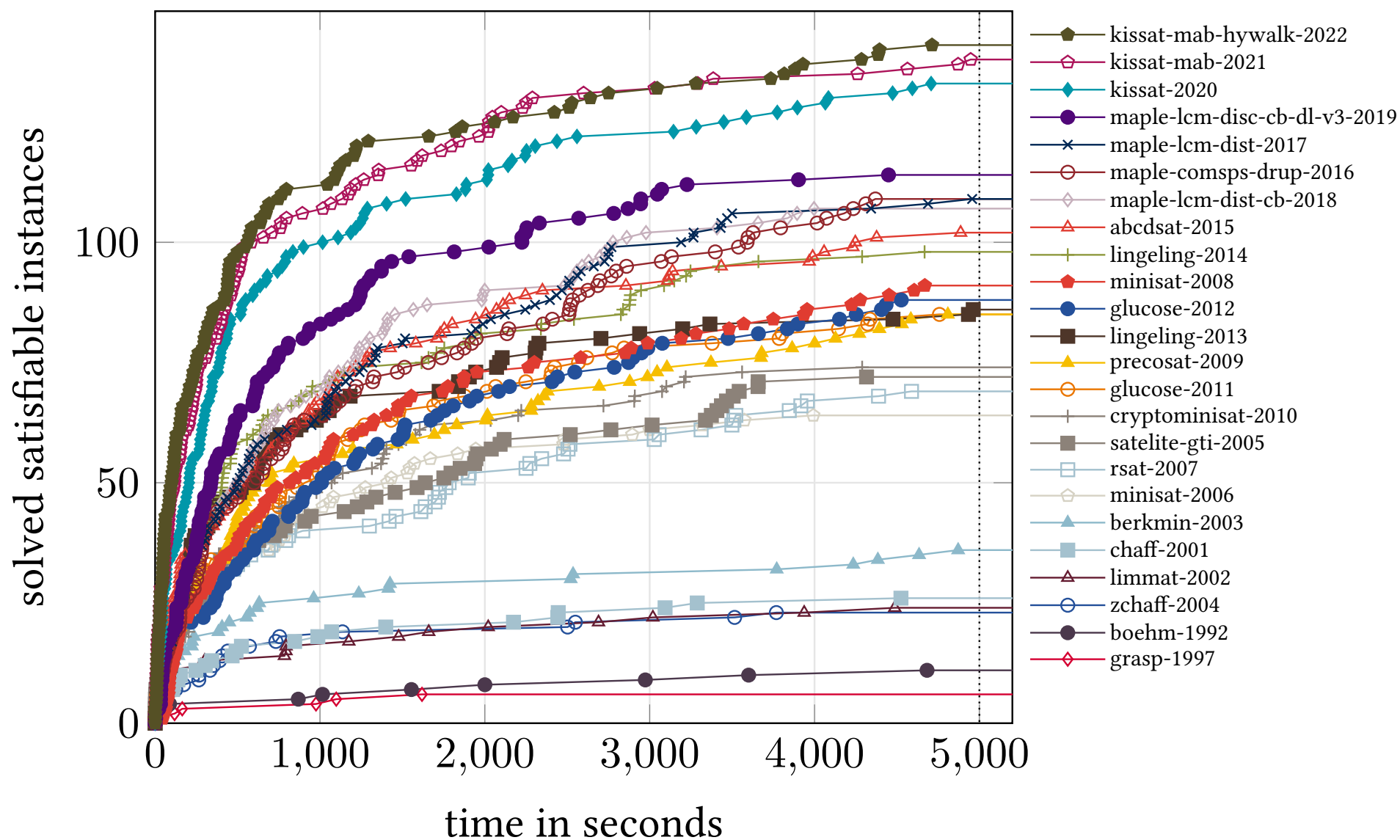
SAT solvers do get faster and faster!

- 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

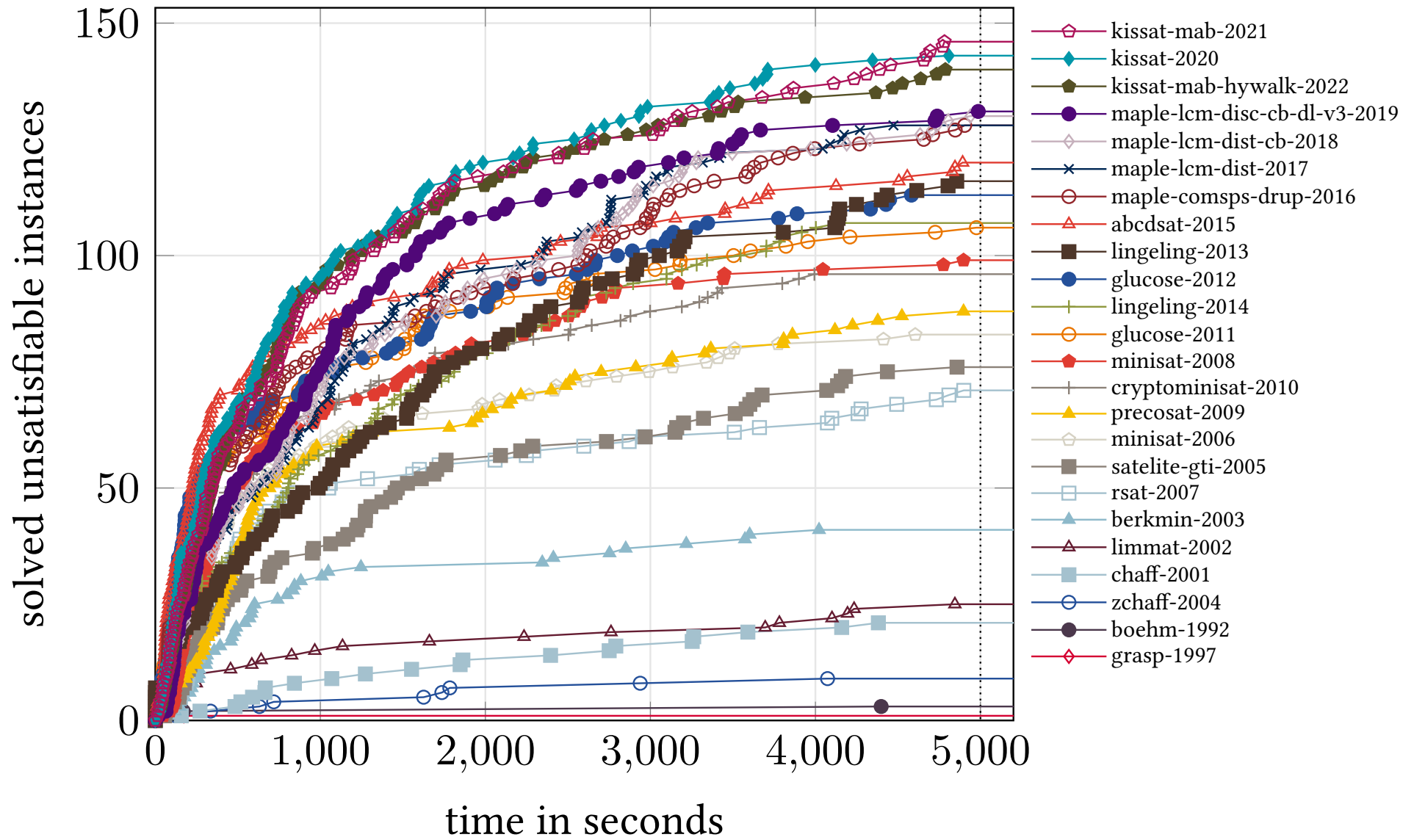
All-Time Winners — SAT Competition 2022 — Solved



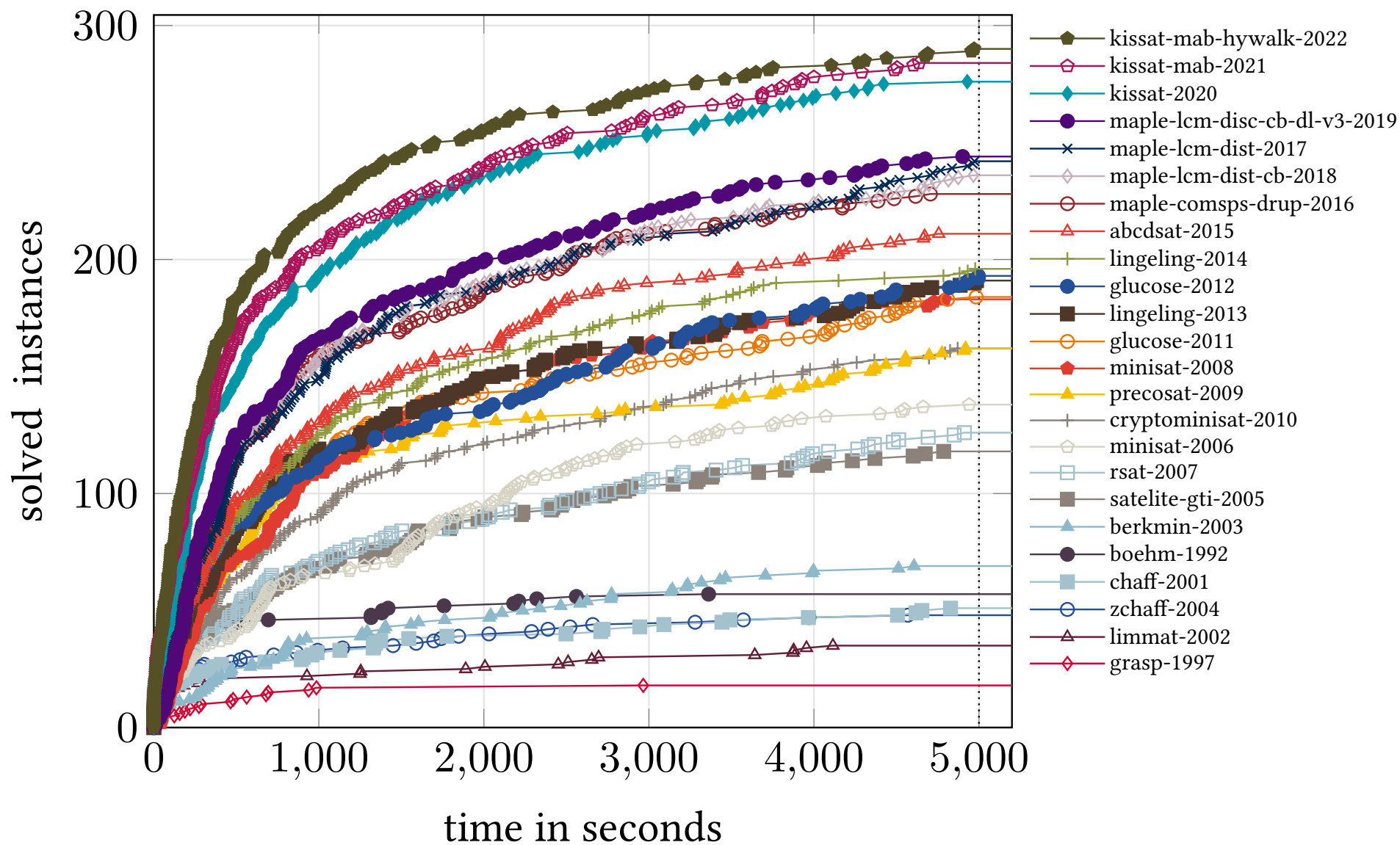
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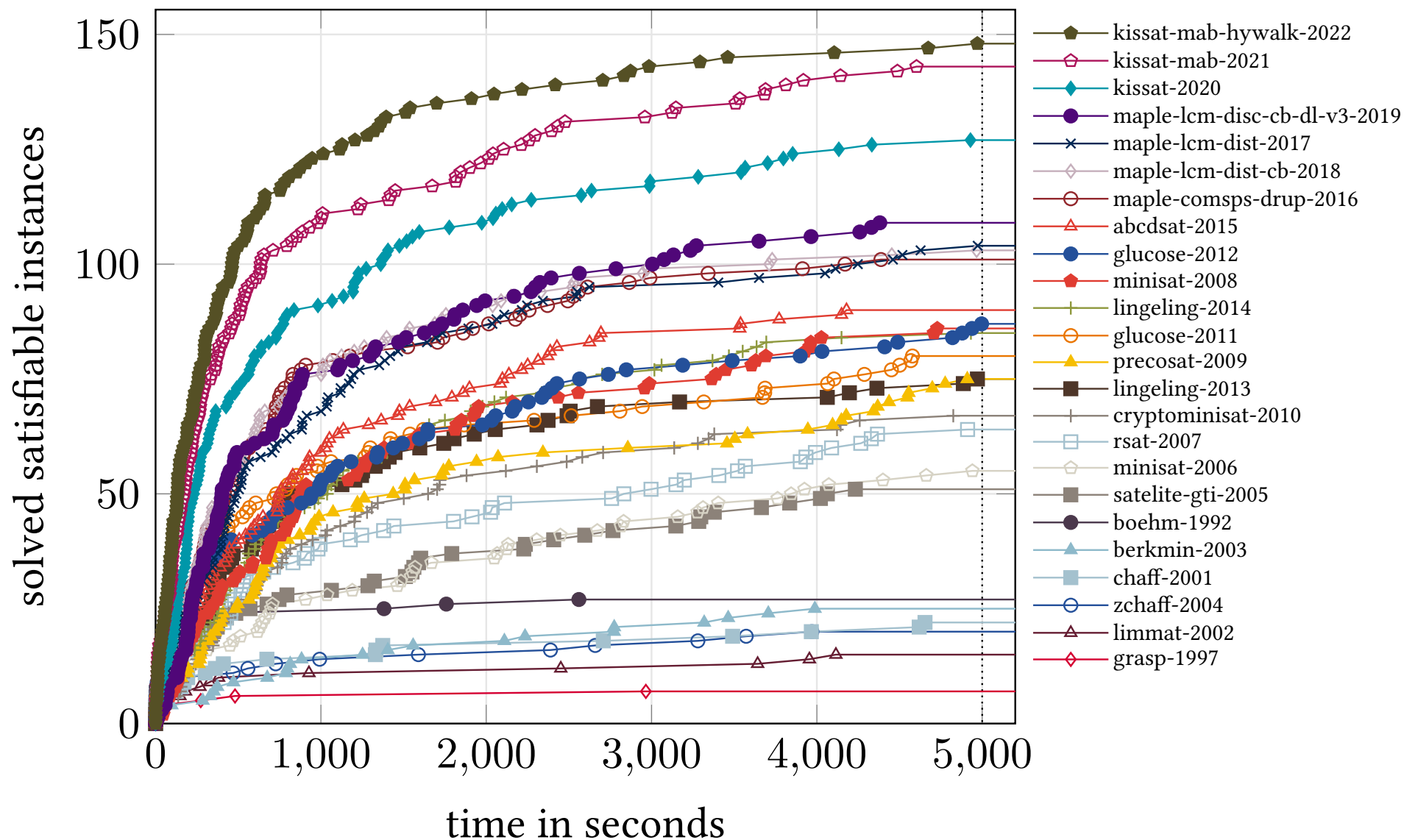
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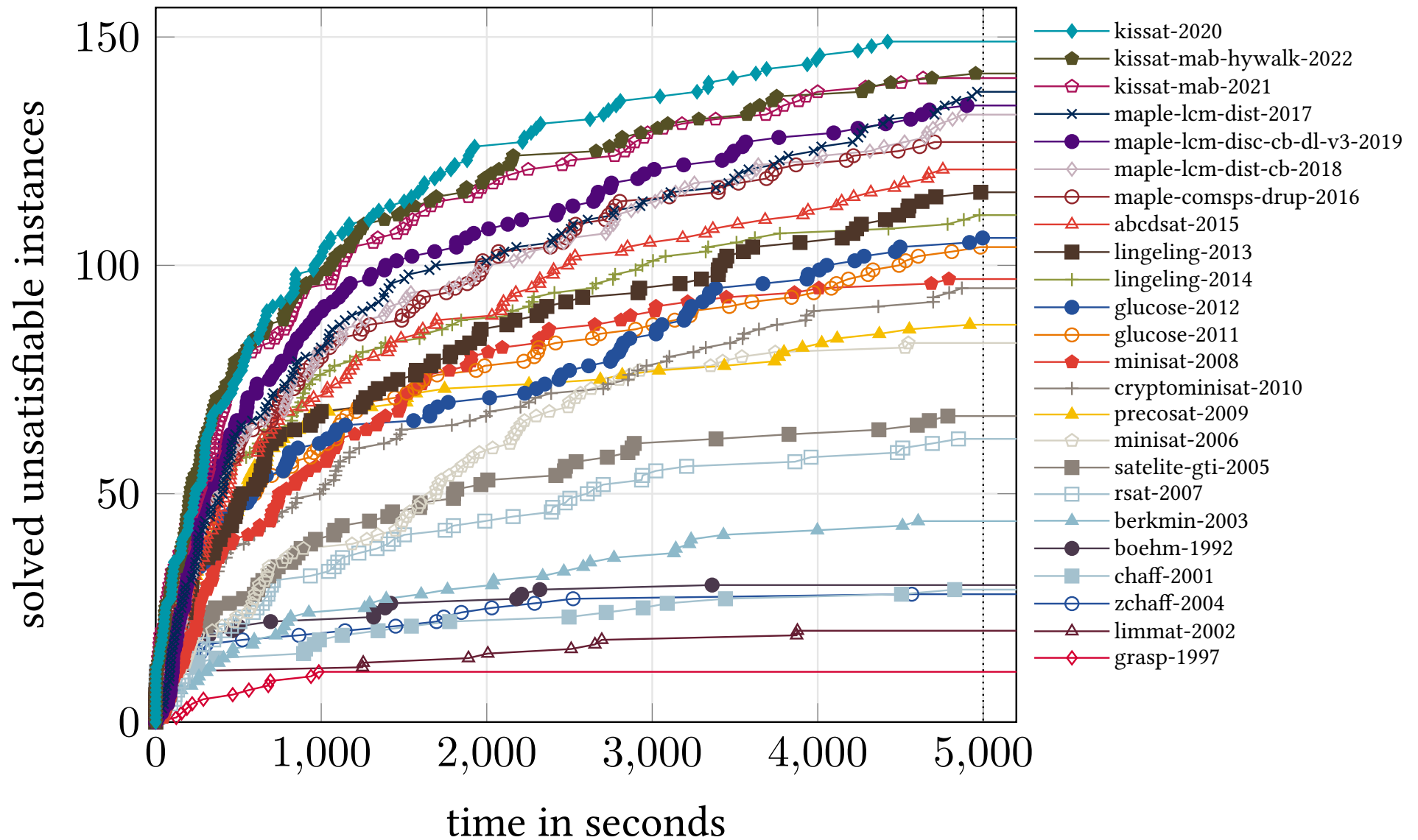
All-Time Winners — SAT Competition 2021 — Solved



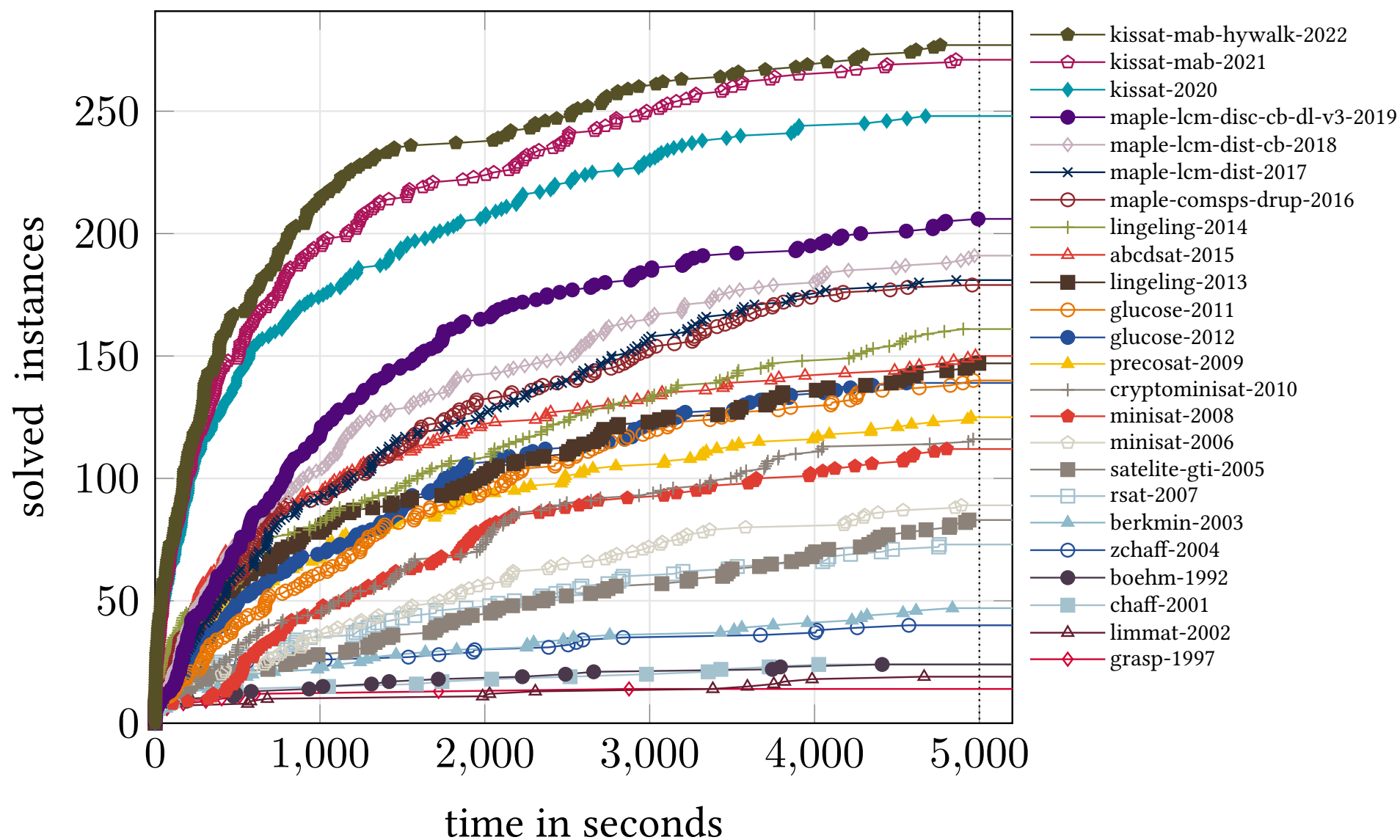
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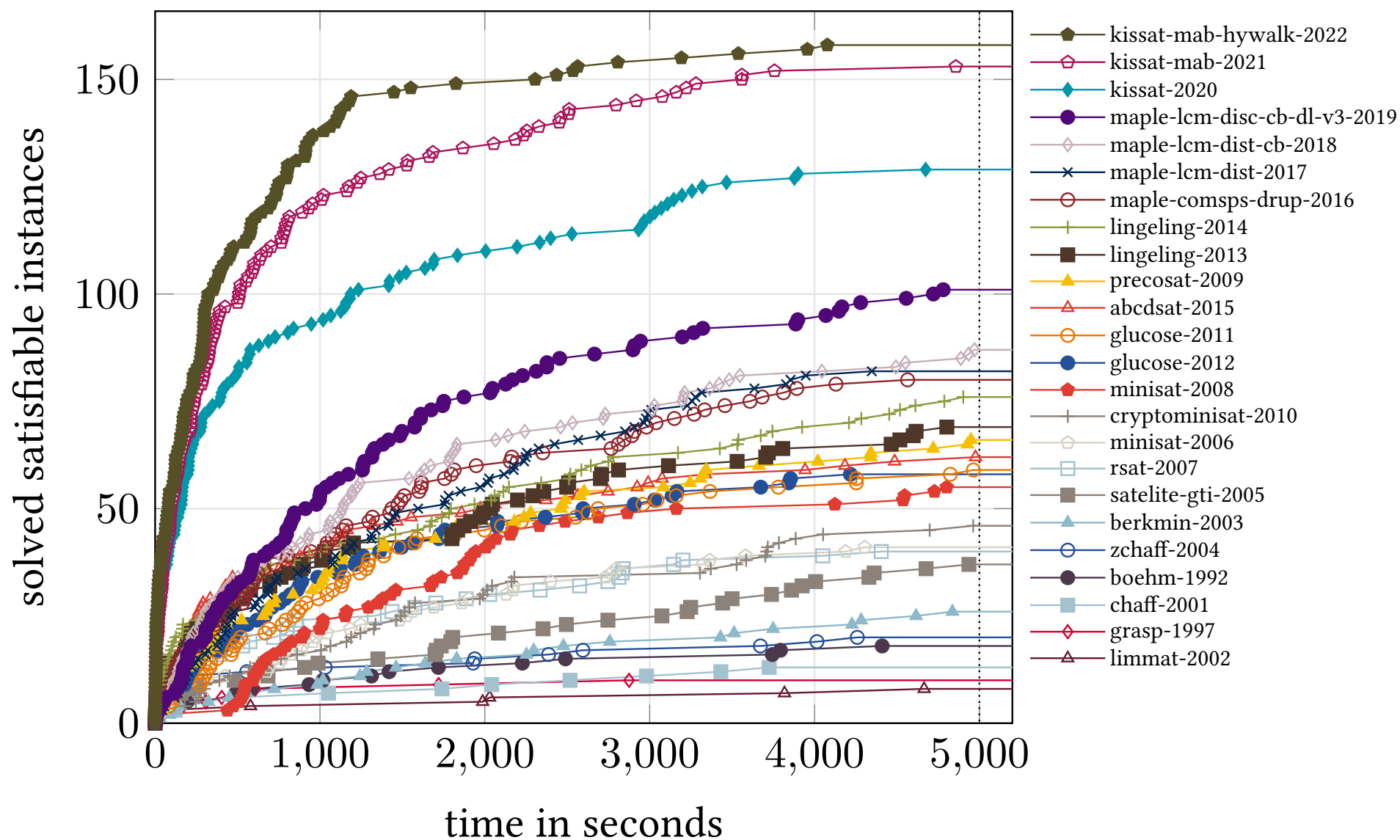
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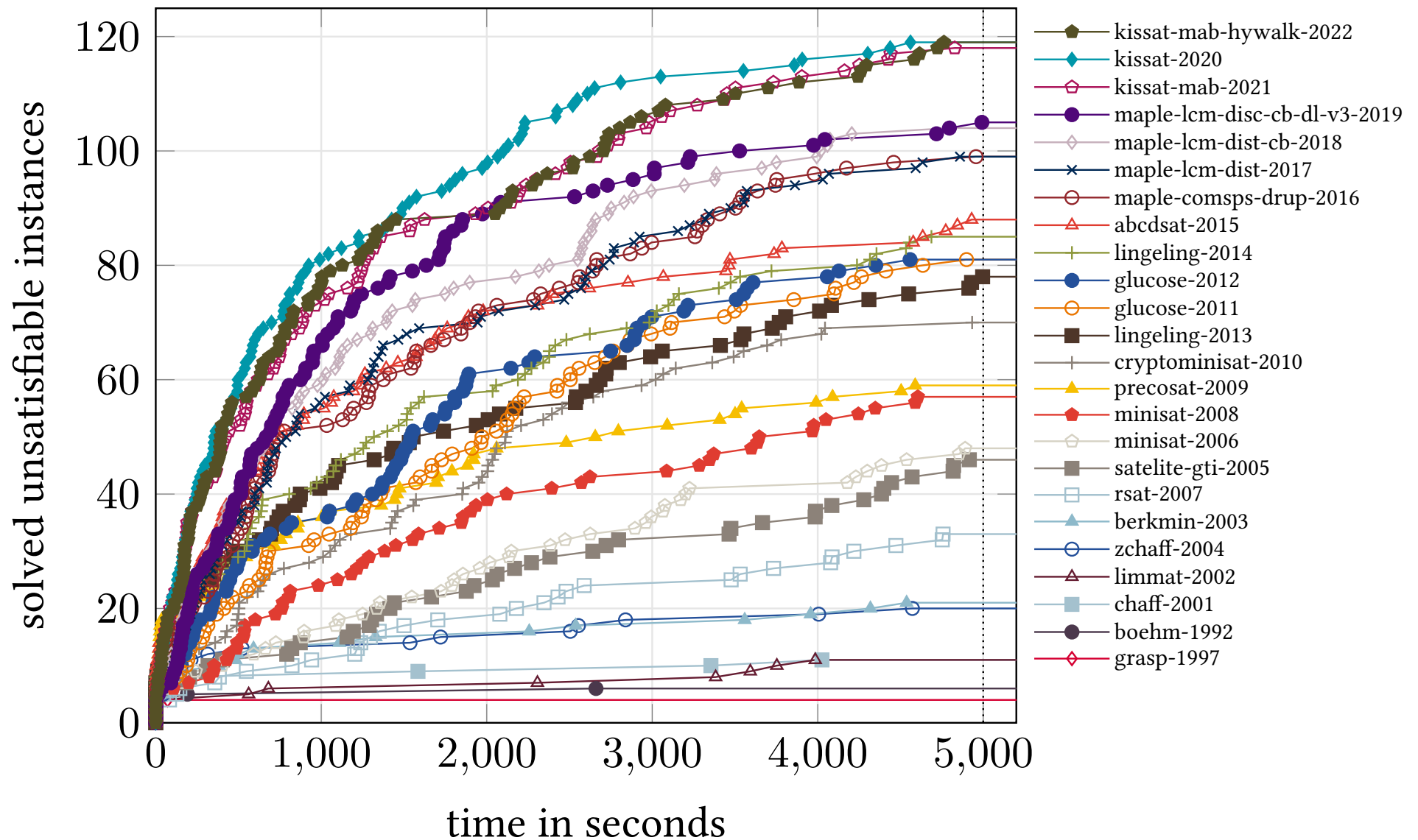
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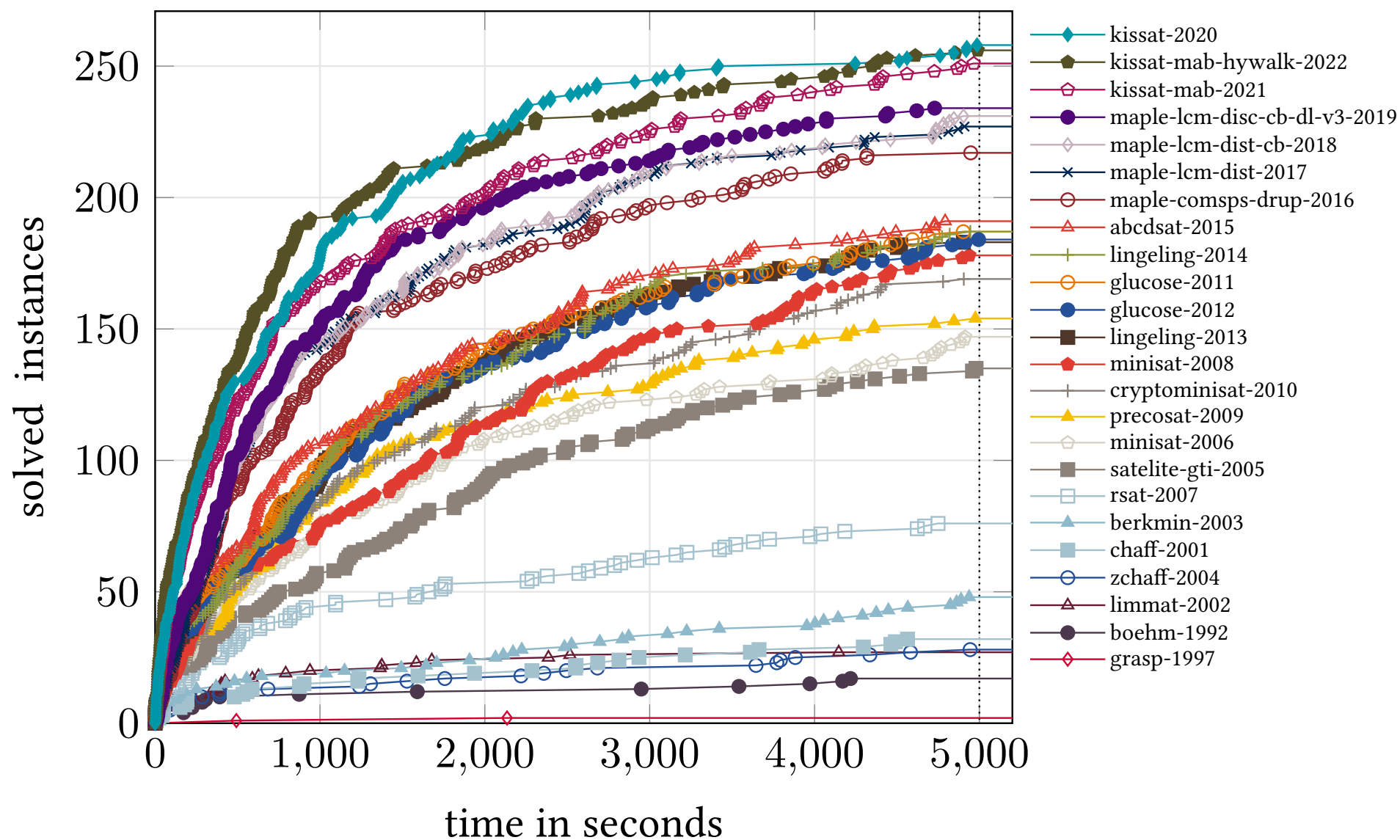
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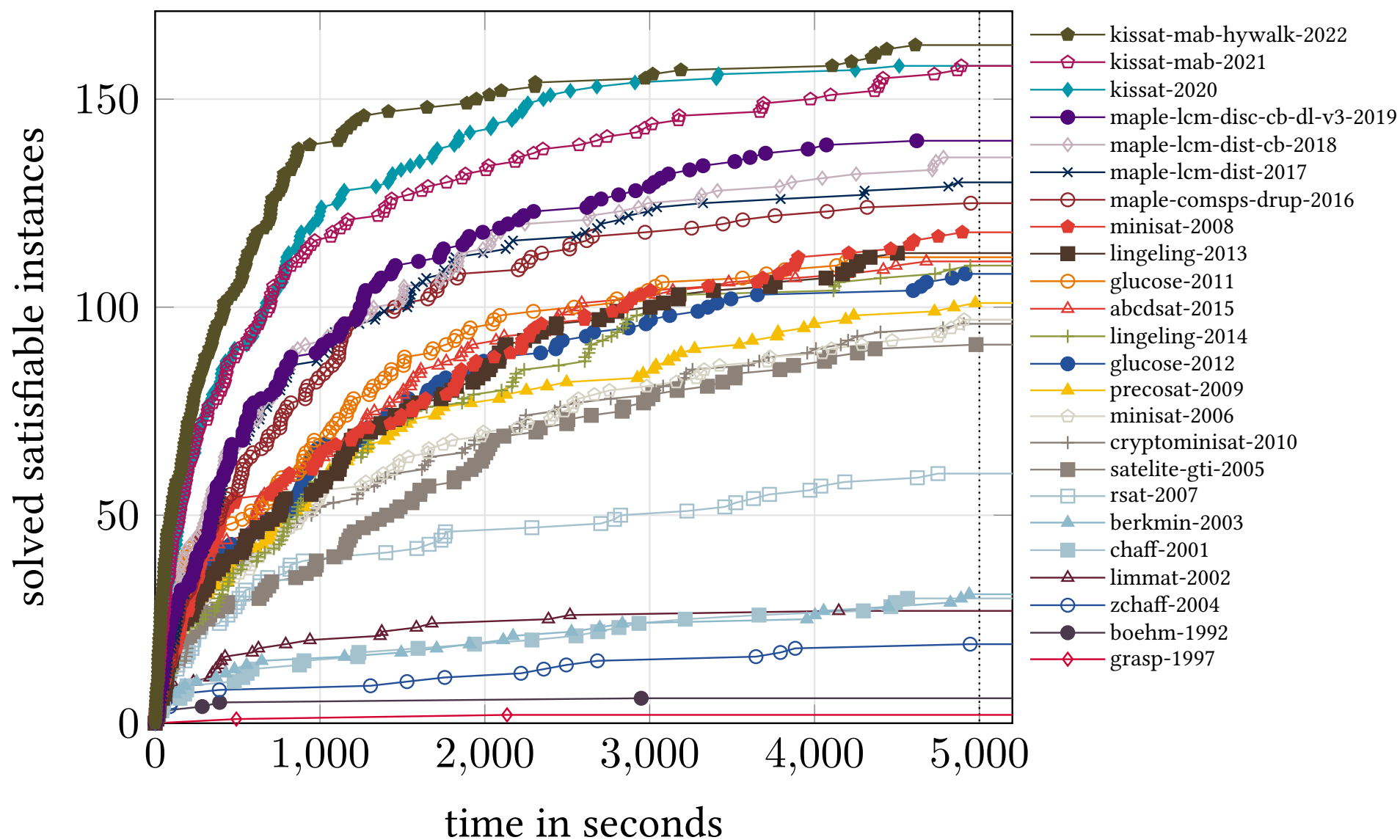
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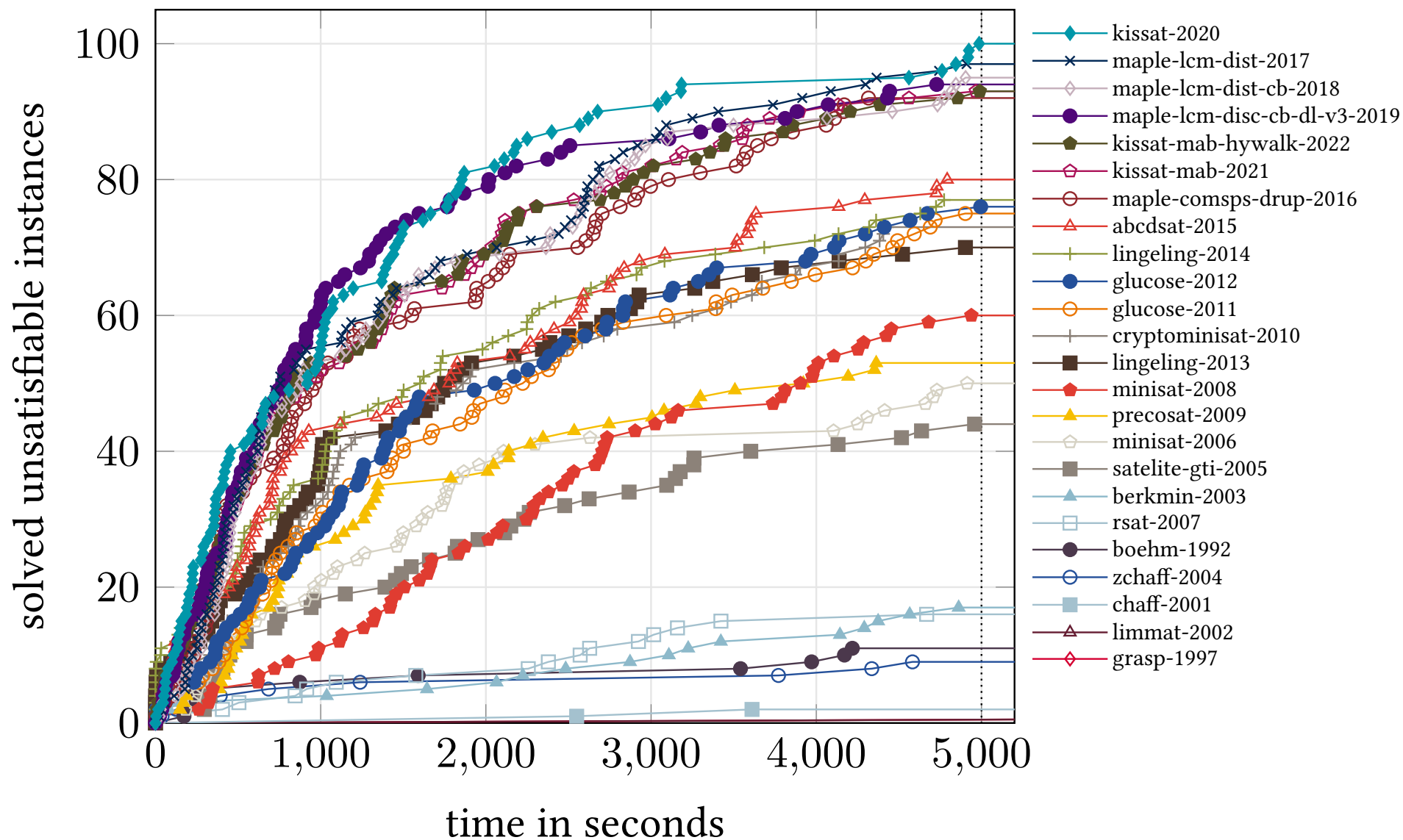
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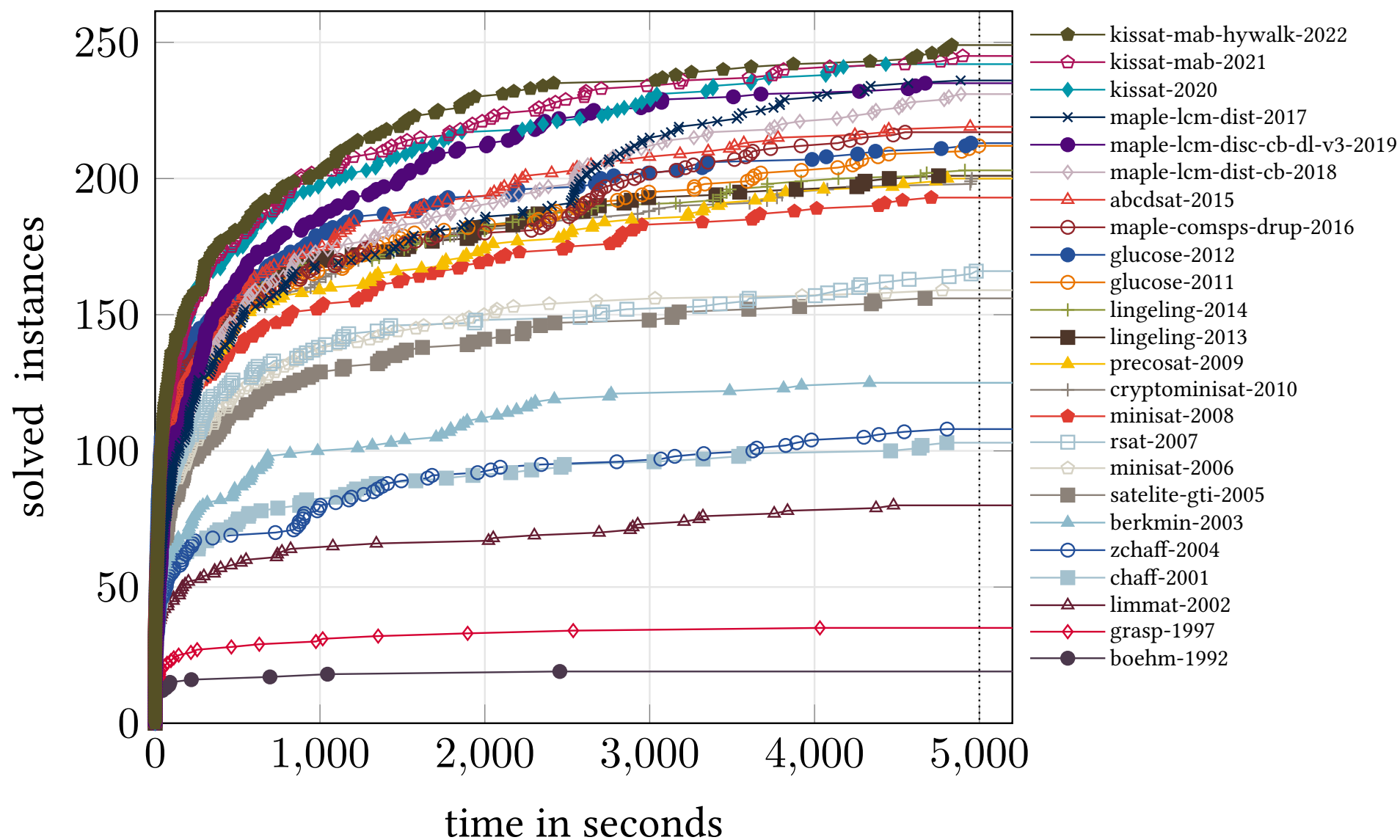
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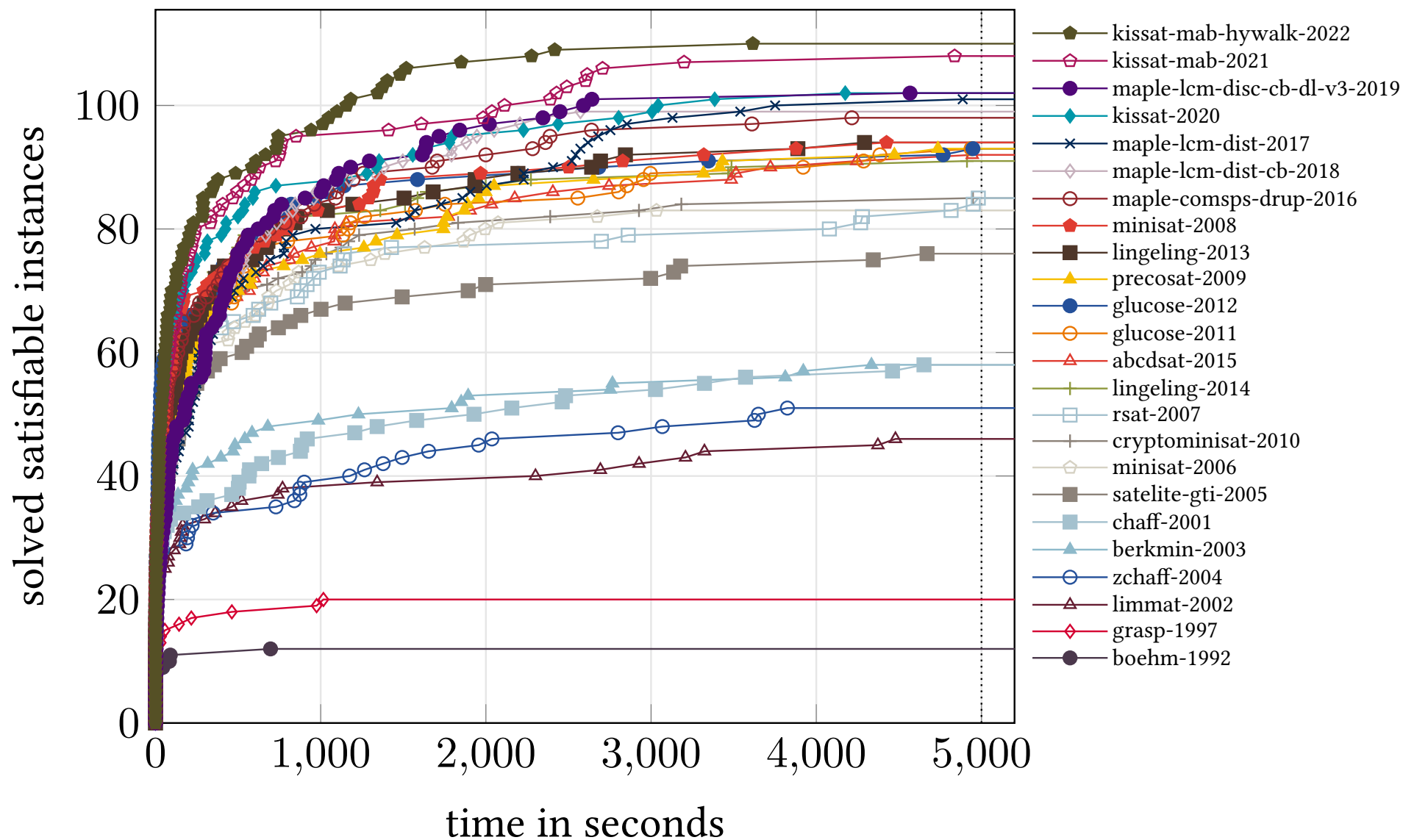
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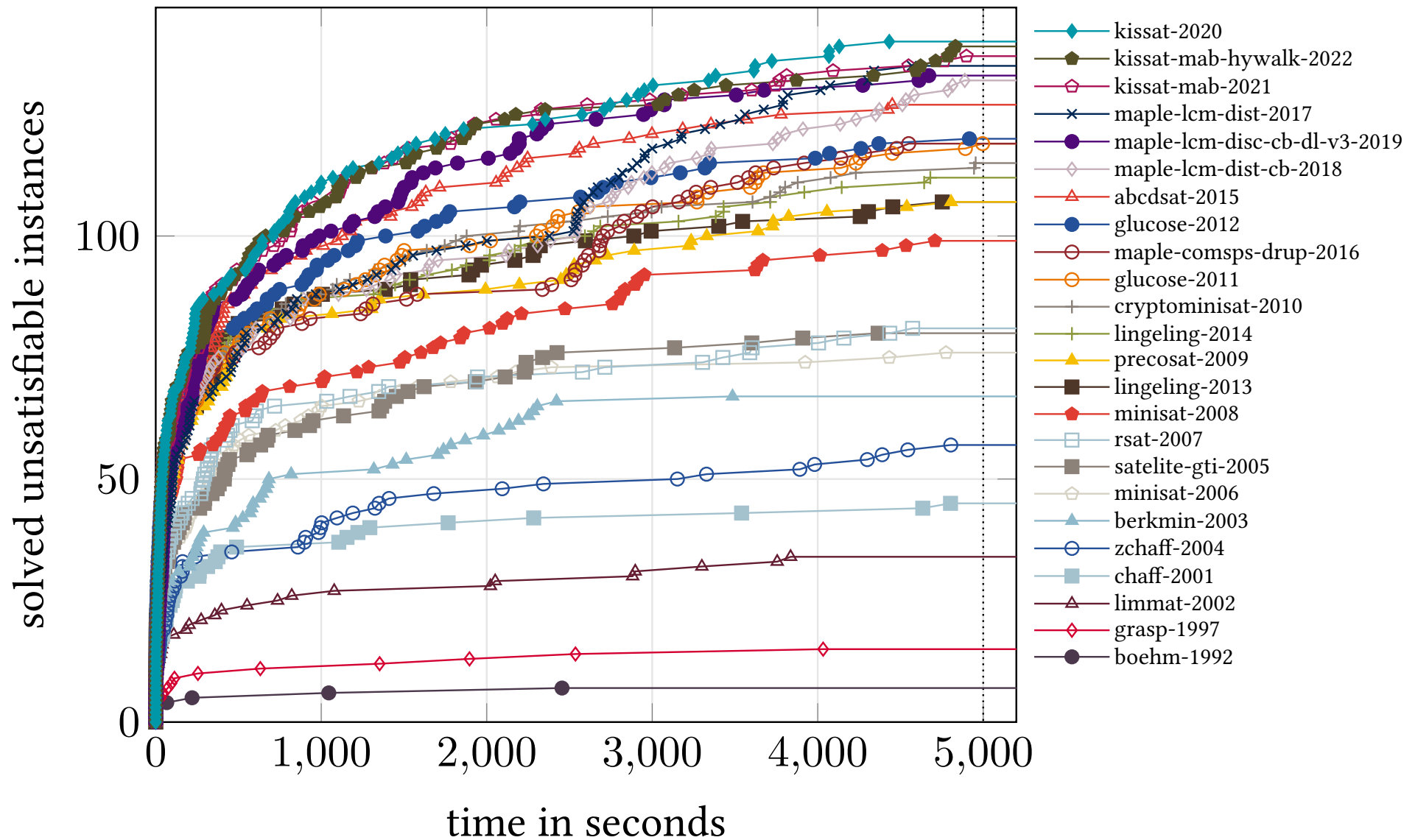
All-Time Winners — SAT Competition 2011 — Solved



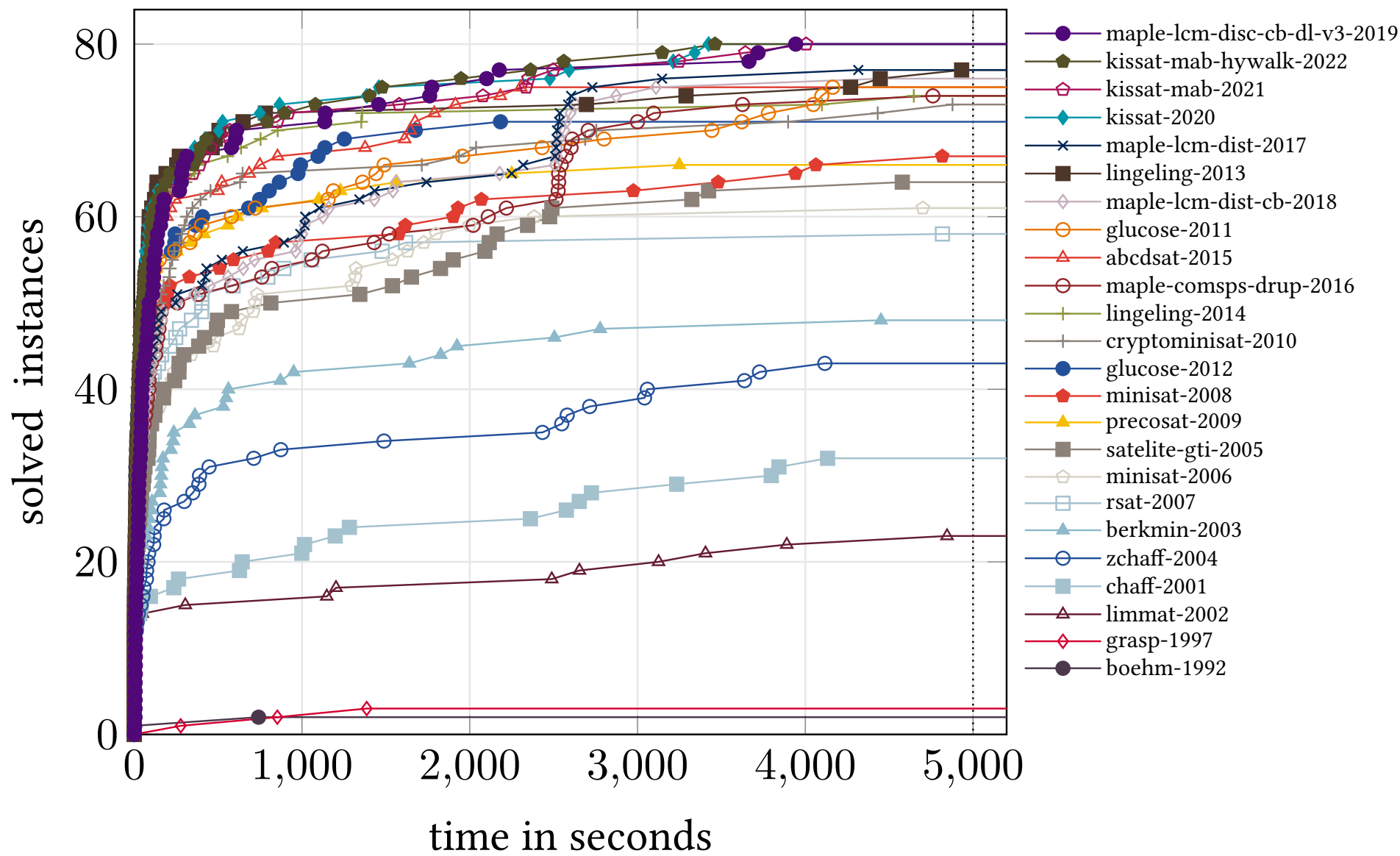
All-Time Winners — SAT Competition 2011 — Satisfiable



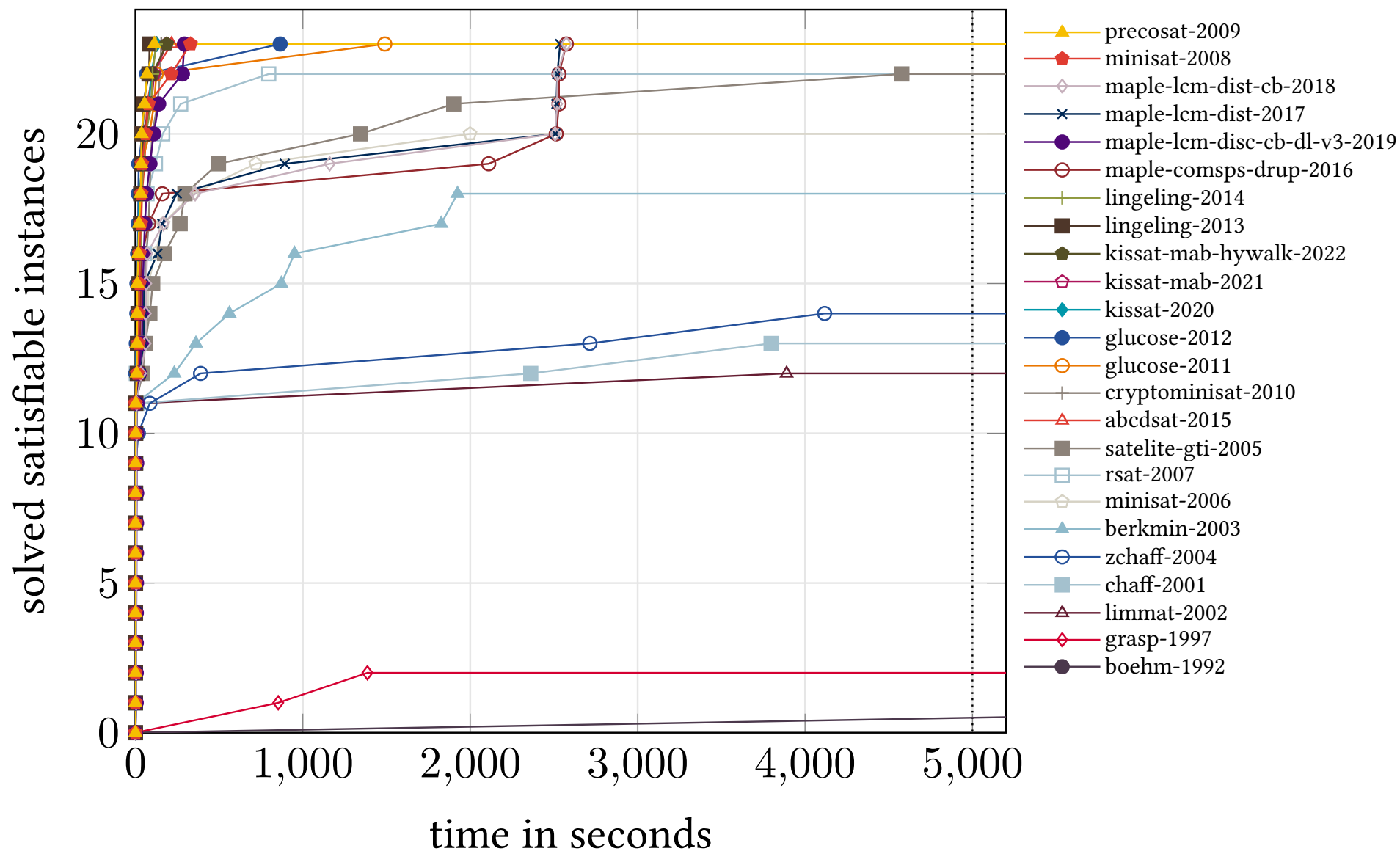
All-Time Winners — SAT Competition 2011 — Unsatisfiable



All-Time Winners — SAT Competition 2002 — Solved



All-Time Winners — SAT Competition 2002 — Satisfiable



All-Time Winners — SAT Competition 2002 — Unsatisfiable

