

The Effect of Scrambling CNFs

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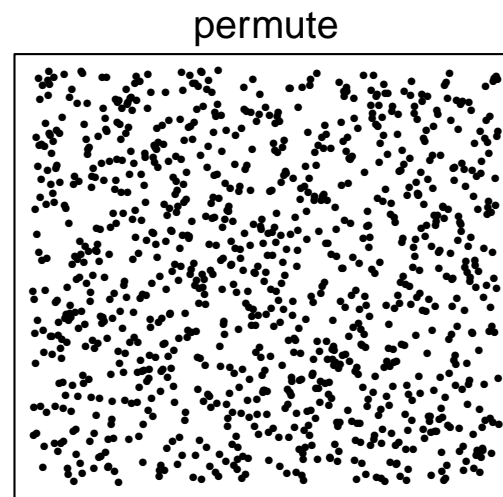
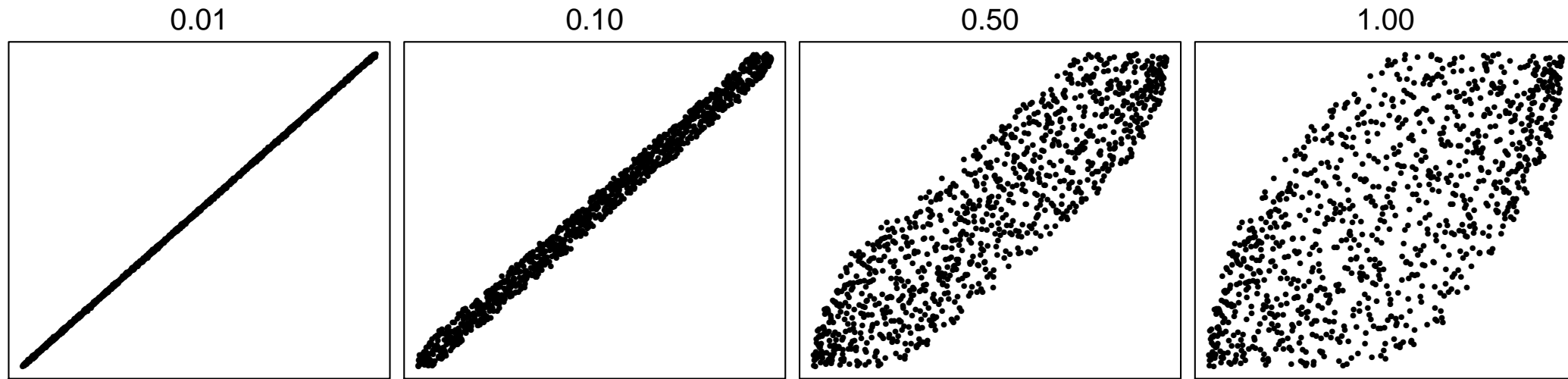
Federated Logic Conference 2018 (FLoC'18)

Oxford, UK, July 7, 2018

Scrambling DIMACS

	c only	c only	c clauses reversed
	c variables	c clauses	c first literal flipped
c original	c swapped	c reversed	c variables swapped
p cnf 2 3	p cnf 2 3	p cnf 2 3	p cnf 2 3
-1 -2 0	-2 -1 0	1 -2 0	-2 -1 0
-1 2 0	-2 1 0	-1 2 0	2 1 0
1 -2 0	2 -1 0	-1 -2 0	2 -1 0

Adjustable Scrambling



1035 variables

Idea

Let $S = 0, \dots, n-1$ be the sequence of the first n natural numbers.

Further assume another sequence $d_0, \dots, d_{n-1} \in [0, 1)$.

Generated by a random number generator such as `drand48`.

Scramble result is a permutation $\pi : S \rightarrow S$ which satisfies

$$\text{if } i + w \cdot n \cdot d_i < j + w \cdot n \cdot d_j \text{ then } \pi(i) < \pi(j)$$

for all $0 \leq i, j < n$.

```
int[] scramble (int n, double w, bool permute)

    struct { int src; double pos; } order[n];
    for (int i = 0; i < n; i++) order[i].src = i;
    if (permute)
        for (int i = 0; i < n; i++)
            order[i].pos = drand48 ();
    else
        for (int i = 0; i < n; i++)
            order[i].pos = i + w * n * drand48 ();
    sort (order w.r.t. pos);
    int res[n];
    for (int i = 0; i < n; i++) res[i] = order[i].src;
    return res;
```

Top Solvers Main Track SAT 2017 competition

- focused on top 17 best performing solvers (out of 29 ranked)
- selected one solver from each group of submitters
- this gives the following 7 solvers:

abbreviation	solver name in competition	last names of authors
maplelcm	Maple_LCM_Dist	Xiao, Luo, Li, Manyà, Lü
maplecompmps	MapleCOMSPS_LRB_VSIDS_2_drup	Liang, Oh, Ganesh, Czarnecki, Poupart
compspspulsar	COMiniSatPS_Pulsar_drup	Oh
cadical	cadical-sc17-proof	Biere
tchglucose	tch_glucose3	Moon, Mary
glucose41	glucose-4.1	Audemard, Simon
gluvc	glu_vc	Chen

Score	Total Solved	SAT Solved	UNSAT Solved	Solver Name
1610934.19936	208	102	106 1	Maple_LCM_Dist,default
1640696.51549	206	100	106	Maple_LCM,default
1654244.83466	204	96	108	MapleLRB_LCMoccRestart,default
1676517.64800	198	94	104	MapleLRB_LCM,default
1780711.47396	188	93	95 2	MapleCOMSPS_LRB_VSIDS_2_drup,LRB_VSIDS_2_drup
1798300.37516	188	89	99 3	COMiniSatPS_Pulsar_drup,drup
1805445.41397	185	96	89	MapleCOMSPS_LRB_VSIDS_drup,LRB_VSIDS_drup
1825427.456278	185	83	102 4	cadical-sc17-proof,default
1866002.046356	179	90	89	MapleCOMSPS_CHB_VSIDS_drup,CHB_VSIDS_drup
1890486.936384	179	80	99 5	tch_glucose3,default
1893632.700389	180	85	95 6	glucose-4.1,default
1898402.228997	179	97	82	cadical-sc17-agile-proof,default
1909310.272728	176	86	90	GHackCOMSPS_drup,ghack_drup
1917700.082077	179	82	97	bs_glucose,default
1958463.892502	174	77	97 7	glu_vc,default
2051828.510509	161	82	79	tch_glucose2,default
2057715.184748	162	72	90	tch_glucose1,default
2059608.447912	160	70	90	glucose-3.0+width,default
2071505.753371	162	72	90	Riss7,BVE_DRAT
2124070.48960	154	66	88	lingeling-bbe,default
2152106.935935	150	75	75	Riss7,noPP_DRAT
2176799.16899	147	73	74	satUZK-seq,sge
2187064.479217	146	73	73	abcsat_r17,default
2210323.17325	144	70	74	satUZK-seq,ge
2370968.14664	122	72	50	candy,rsilv
2379124.15318	121	72	49	candy,rsili
2379582.07394	125	75	50	satUZK-seq,sme
2384006.56947	124	73	51	satUZK-seq,me
2414486.85600	118	70	48	Candy,default

Rerunning the competition on JKU cluster

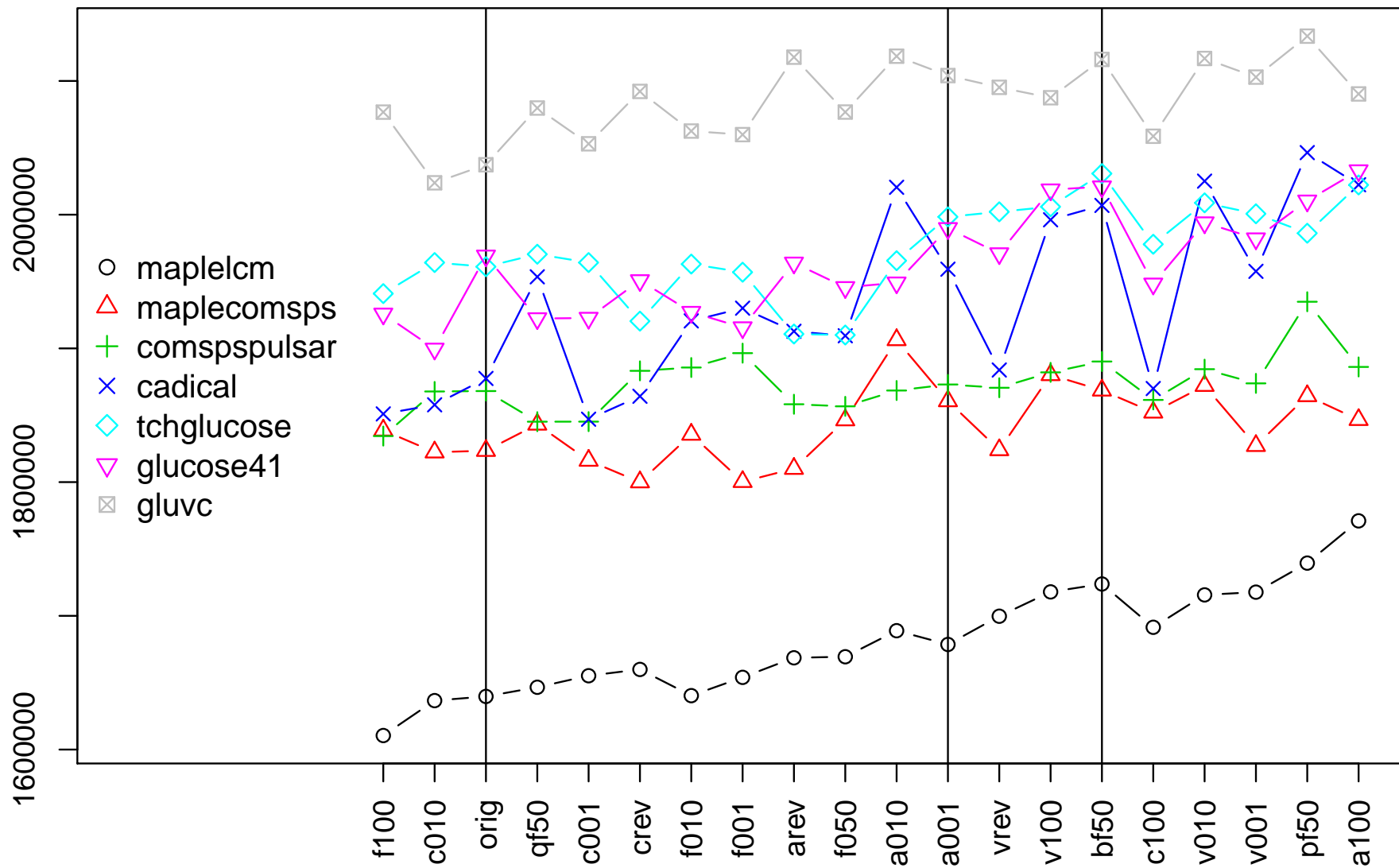
our experiments					SAT 2017 Competition					
rank	par2	solved	sat	uns	rank	par2	solved	sat	uns	
1	1639735	208	101	107	1	1610934	208	102	106	maplelcm
2	1823497	184	90	94	2	1780711	188	93	95	maplecompmps
3	1868096	181	87	94	3	1798300	188	89	99	compspspulsar
4	1877512	180	83	97	4	1825427	185	83	102	cadical
5	1961085	172	77	95	5	1890486	179	80	99	tchglucose
6	1969231	171	79	92	6	1893632	180	85	95	glucose41
7	2037362	165	73	92	7	1958463	174	77	97	gluvc

Considered Scramblings

with options of our tool `scranfilize`

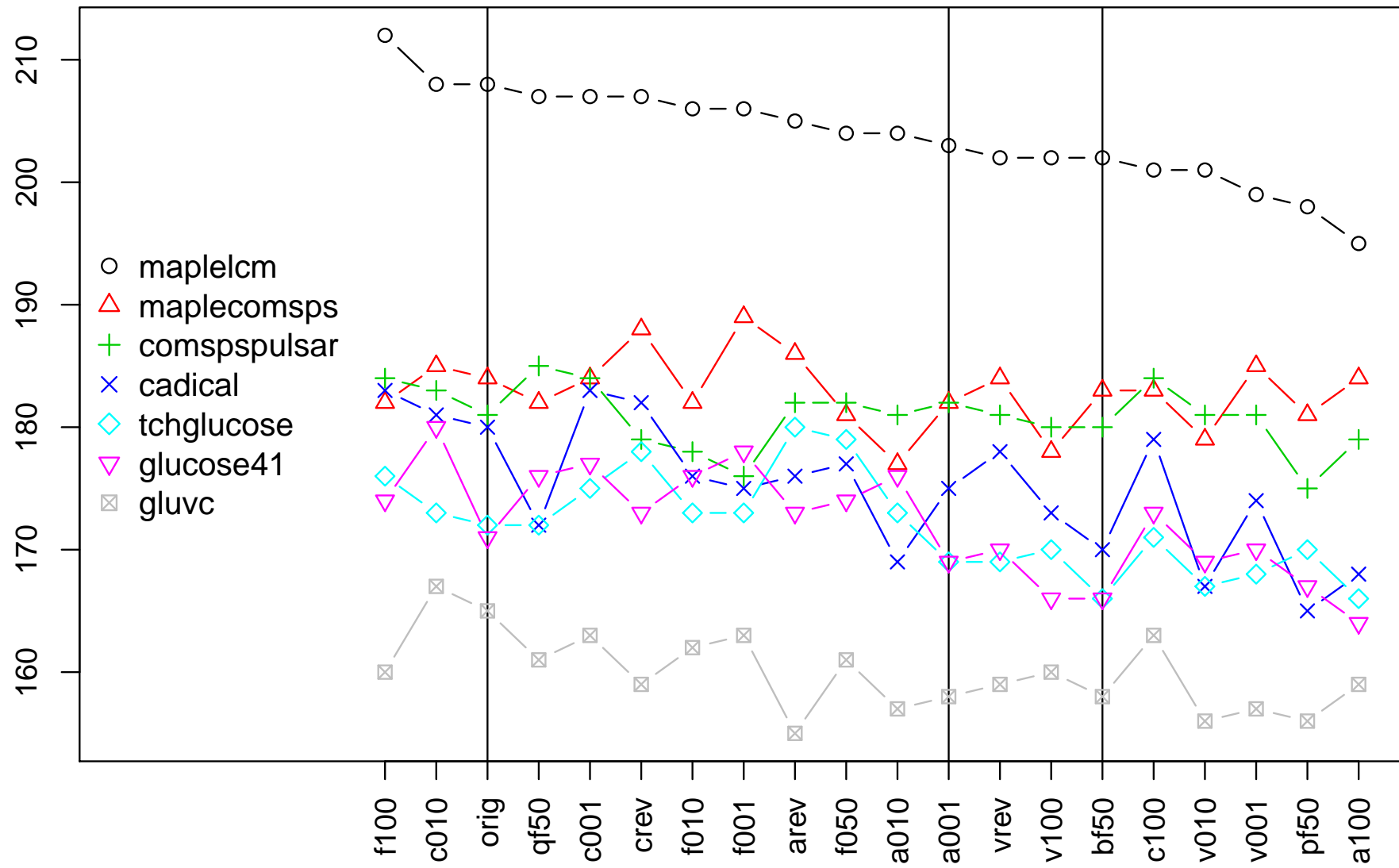
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	variables	clauses	variables	clauses	probability	move window	
	-p	-P	-r	-R	literals	variables	clauses
					-f	-v	-c
* orig							
vrev			1				
crev				1			
pf50	1				0.50		
qf50		1			0.50		
* bf50	1	1			0.50		
f001					0.01		
f010					0.10		
f050					0.50		
f100					1.00		
v001						0.01	
v010						0.10	
v100						1.00	
c001							0.01
c010							0.10
c100							1.00
* a001					0.01	0.01	0.01
a010					0.10	0.10	0.10
a100					0.50	1.00	1.00

Par2 score [main](#) track SAT [2017](#) competition

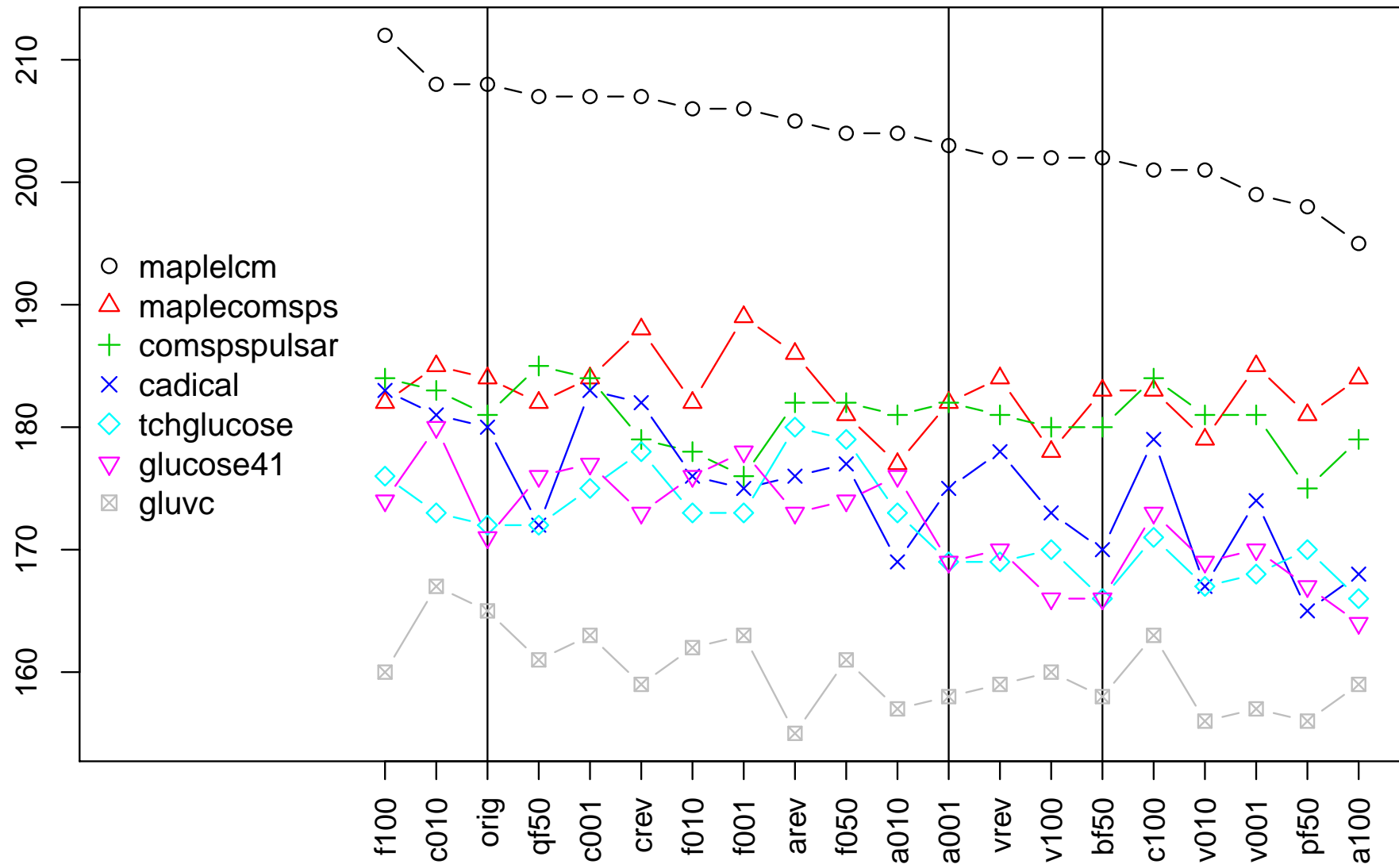


scramblings on x-axis sorted by number of solved instances by "maplelcm"

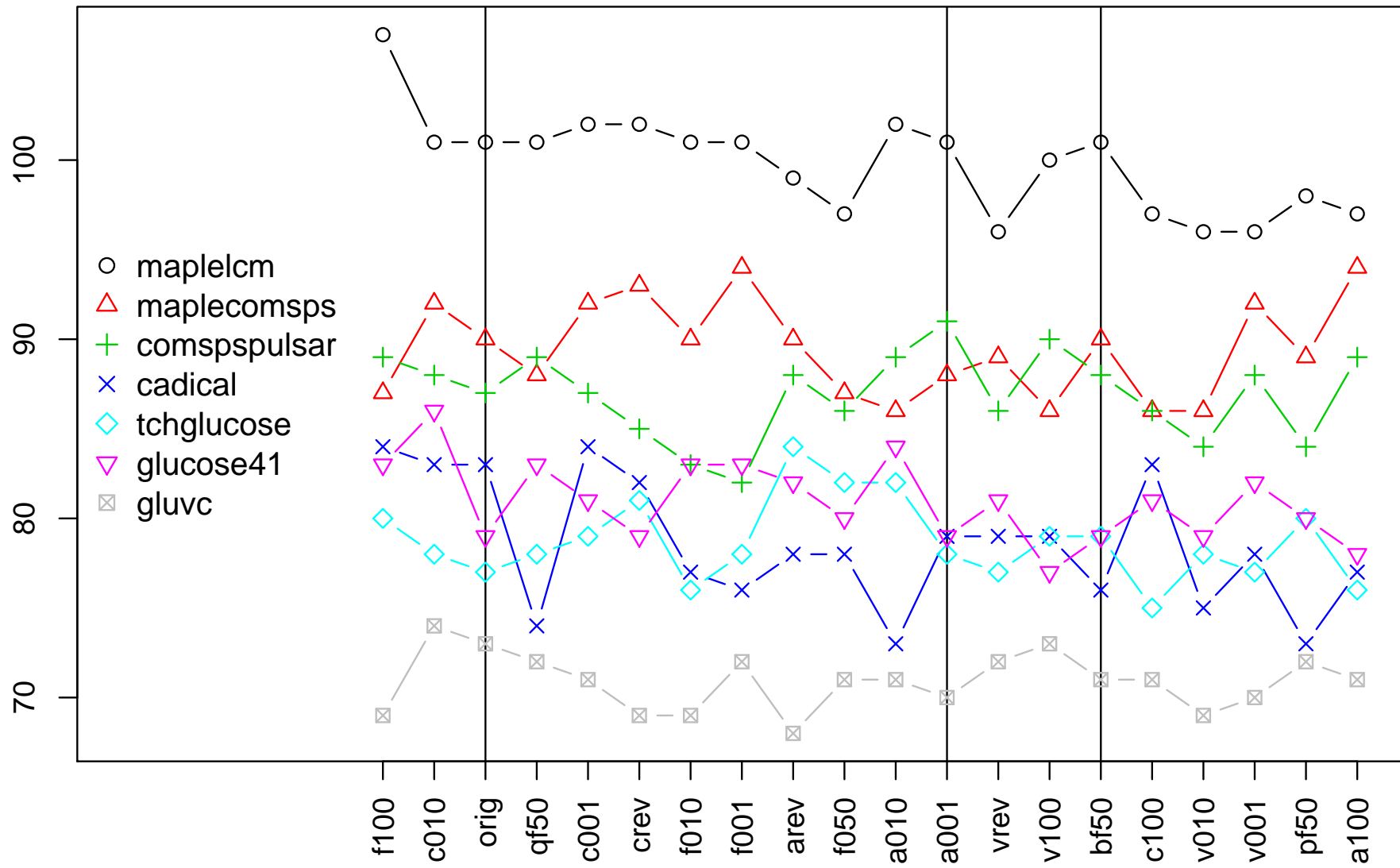
Solved instances [main](#) track SAT [2017](#) competition



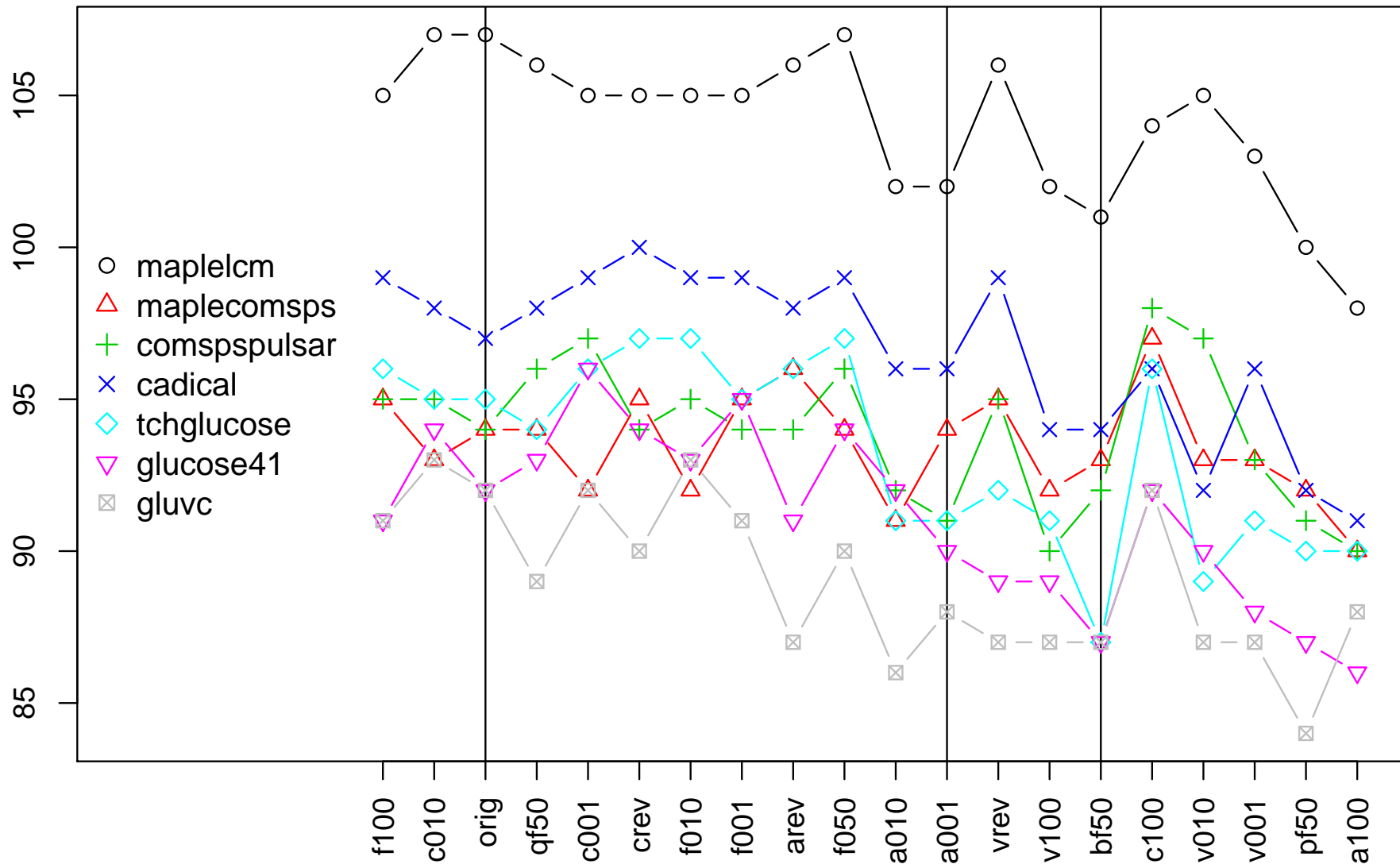
Solved instances [main](#) track SAT [2017](#) competition



Solved satisfiable instances main track SAT 2017 competition



Solved unsatisfiable instances main track SAT 2017 competition



Ranking in main track SAT 2017 competition

	par2			solved			sat			unsat		
	<i>o</i>	μ	σ	<i>o</i>	μ	σ	<i>o</i>	μ	σ	<i>o</i>	μ	σ
maplelcm	1	1.00	0.00	1	1.00	0.00	1	1.00	0.00	1	1.00	0.00
maplecomsps	2	2.10	0.31	2	2.40	0.60	2	2.30	0.47	4	3.85	1.31
comspspulsar	3	3.00	0.46	3	2.75	0.64	3	2.75	0.55	5	3.95	1.05
cadical	4	4.40	0.88	4	4.40	0.88	4	5.10	0.85	2	2.25	0.64
tchglucose	5	5.40	0.75	5	5.35	0.75	6	5.35	0.75	3	4.50	1.05
glucose41	6	5.10	0.72	6	5.10	0.85	5	4.50	0.76	6	5.55	0.83
gluvc	7	7.00	0.00	7	7.00	0.00	7	7.00	0.00	7	6.90	0.31

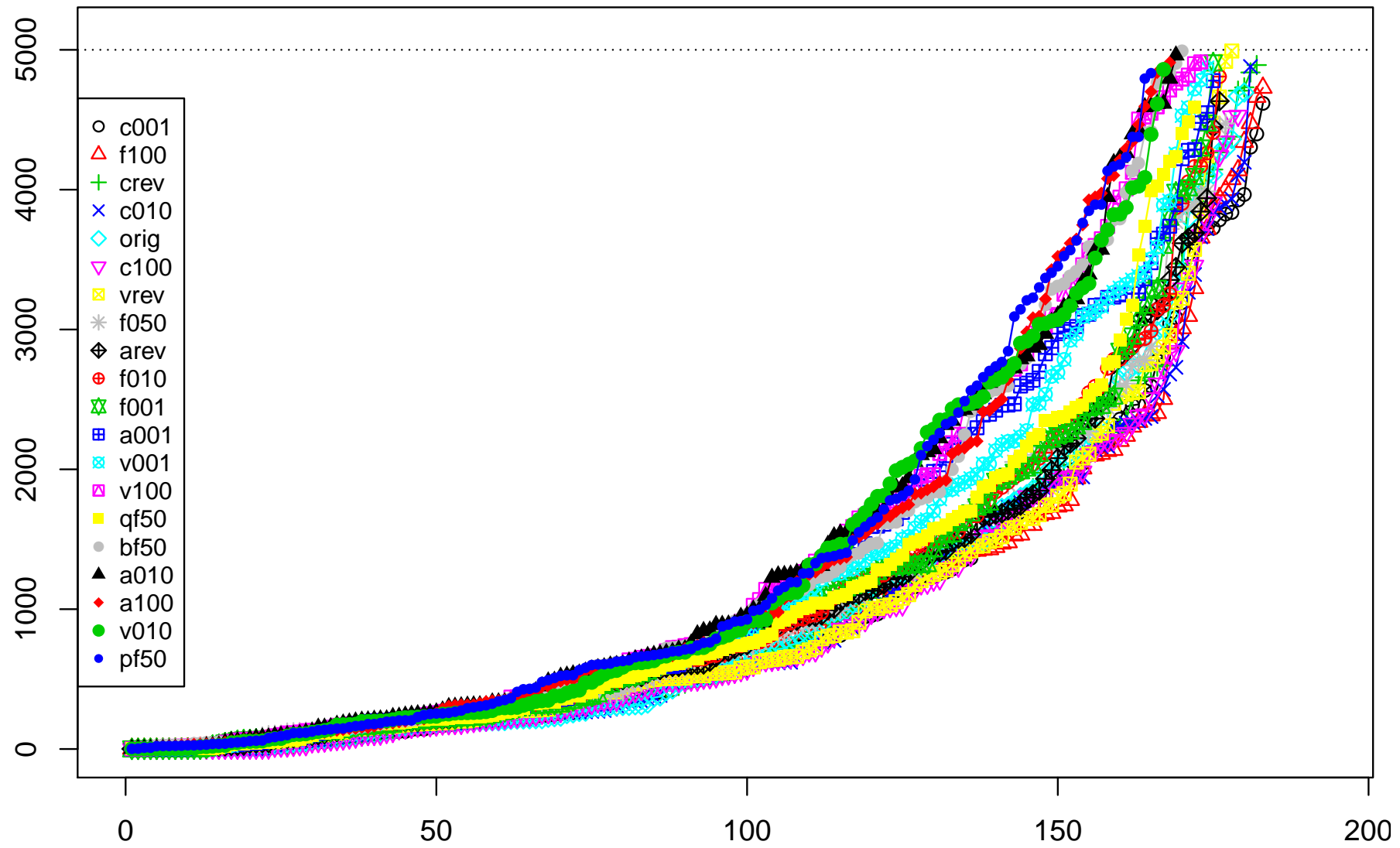
o original μ average σ standard deviation

Scores in main track SAT 2017 competition

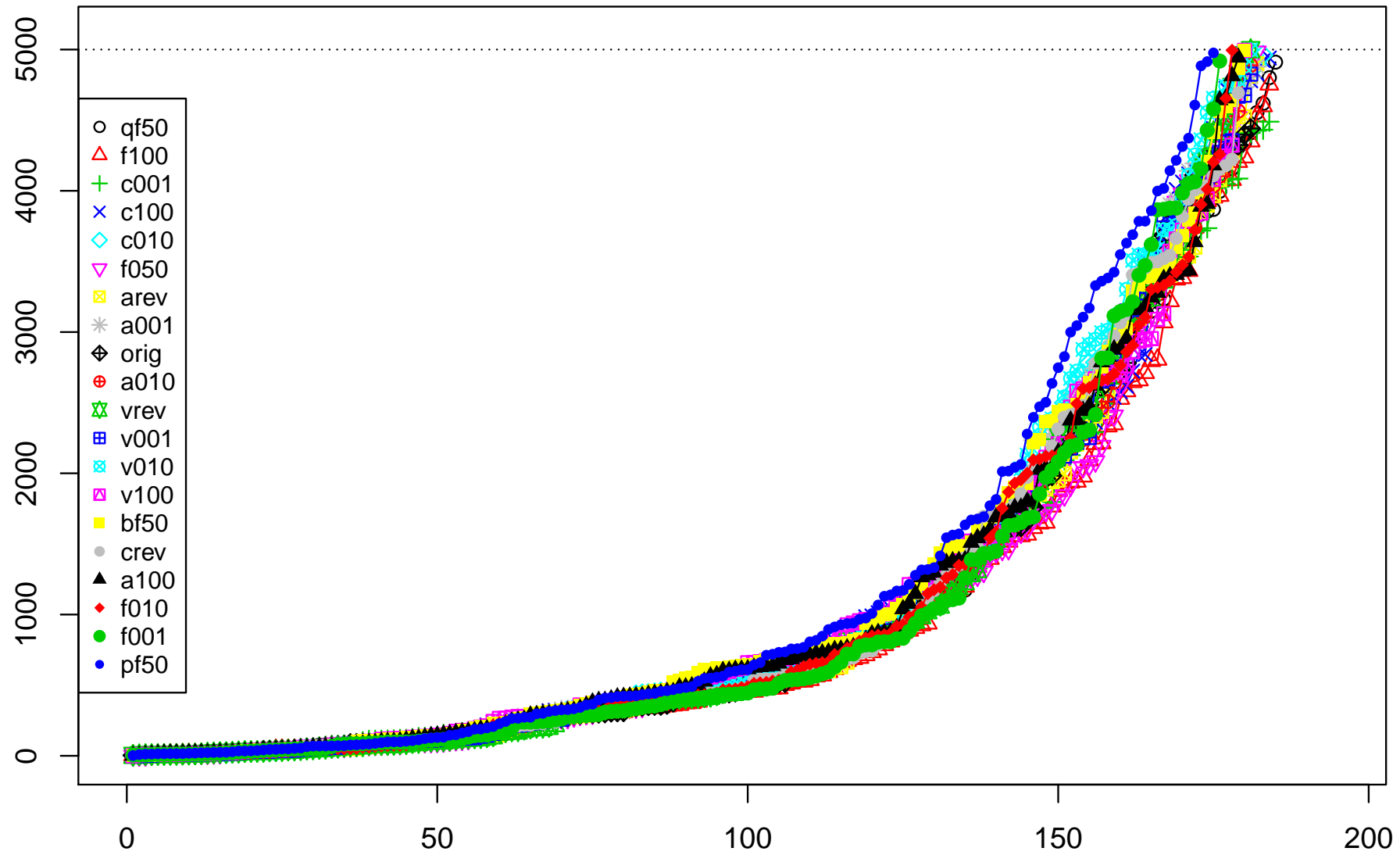
	par2			solved			sat			unsat		
	<i>o</i>	μ	σ	<i>o</i>	μ	σ	<i>o</i>	μ	σ	<i>o</i>	μ	σ
maplelcm	1639735	1681268	40656	208	203.85	4.00	101	99.80	2.78	107	104.05	2.50
maplecomsps	1823497	1841931	27838	184	182.95	3.00	90	89.45	2.70	94	93.50	1.73
comspspulsar	1868096	1873304	21828	181	180.90	2.61	87	86.95	2.42	94	93.95	2.35
cadical	1877512	1935606	66136	180	175.15	5.41	83	78.55	3.59	97	96.60	2.72
tchglucose	1961085	1973028	34740	172	172.00	4.09	77	78.70	2.27	95	93.30	3.10
glucose41	1969231	1963012	38947	171	172.10	4.42	79	80.95	2.28	92	91.15	2.85
gluvc	2037362	2085159	29408	165	159.95	3.19	73	70.90	1.59	92	89.05	2.61

o original μ average σ standard deviation

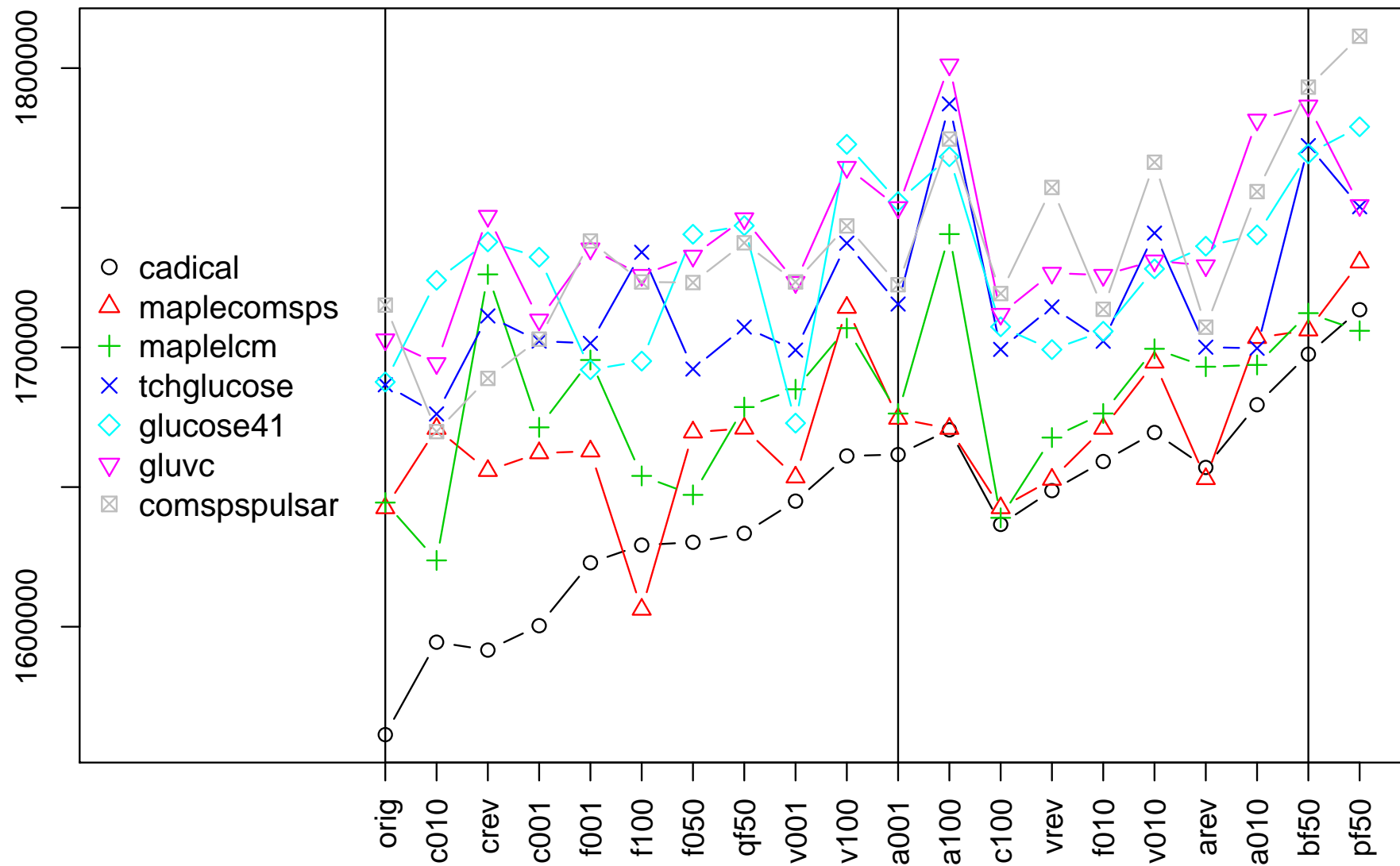
Main track SAT 2017 Competition most sensitive solver “cadical”



Main track SAT 2017 Competition most robust solver “compspulsar”

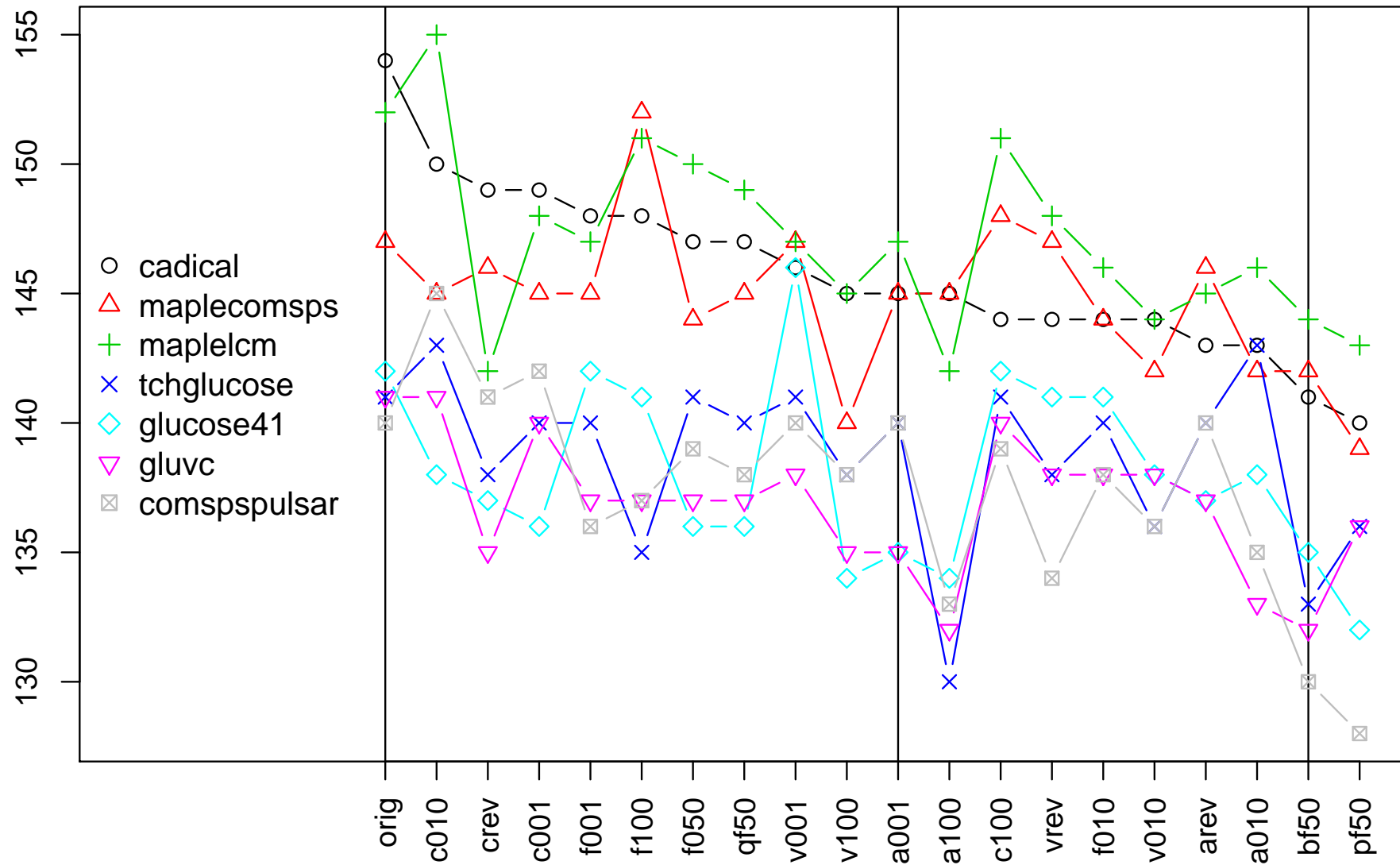


Par2 score application track SAT 2016 competition

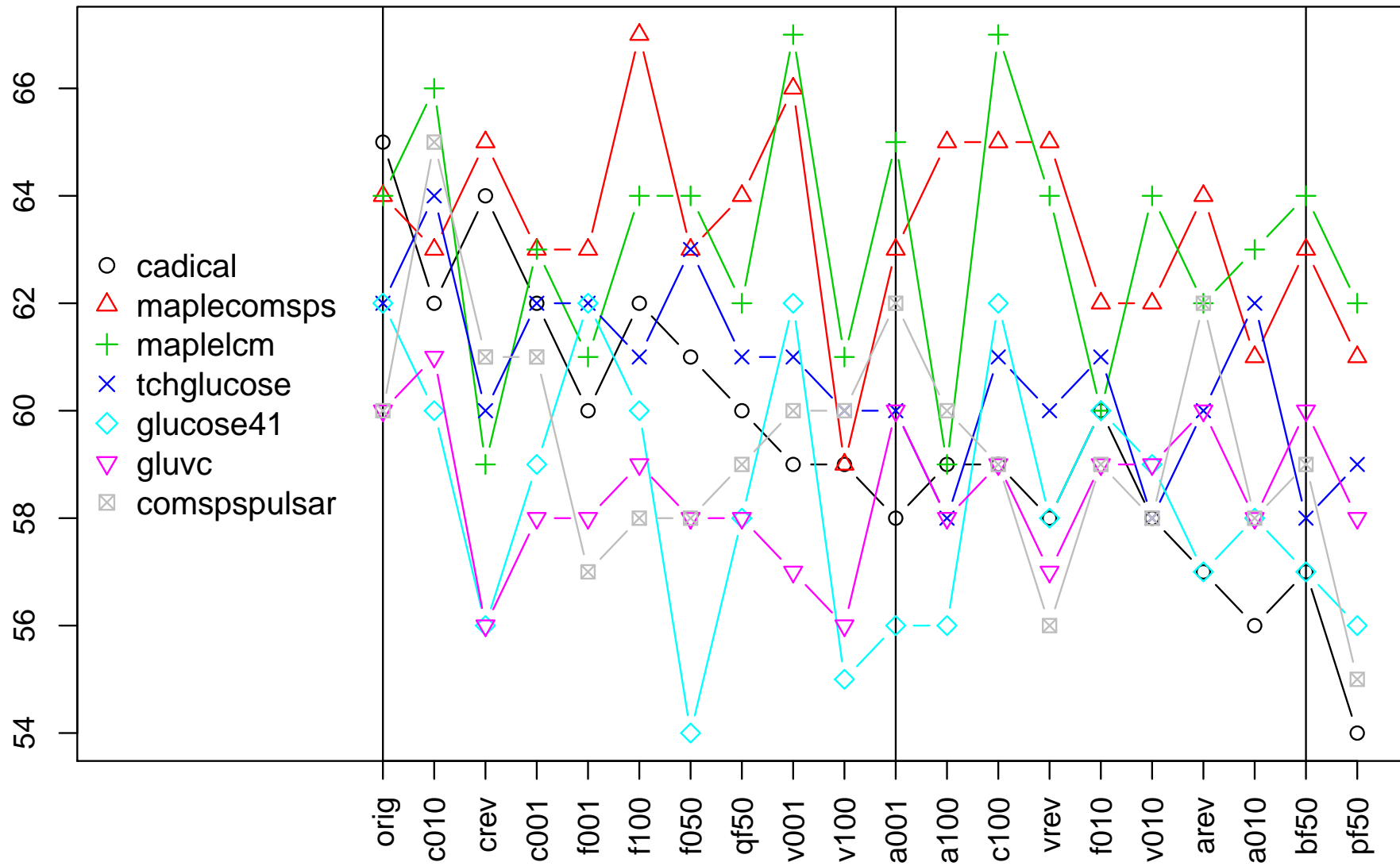


scramblings on x-axis sorted by number of solved instances by "cadical"

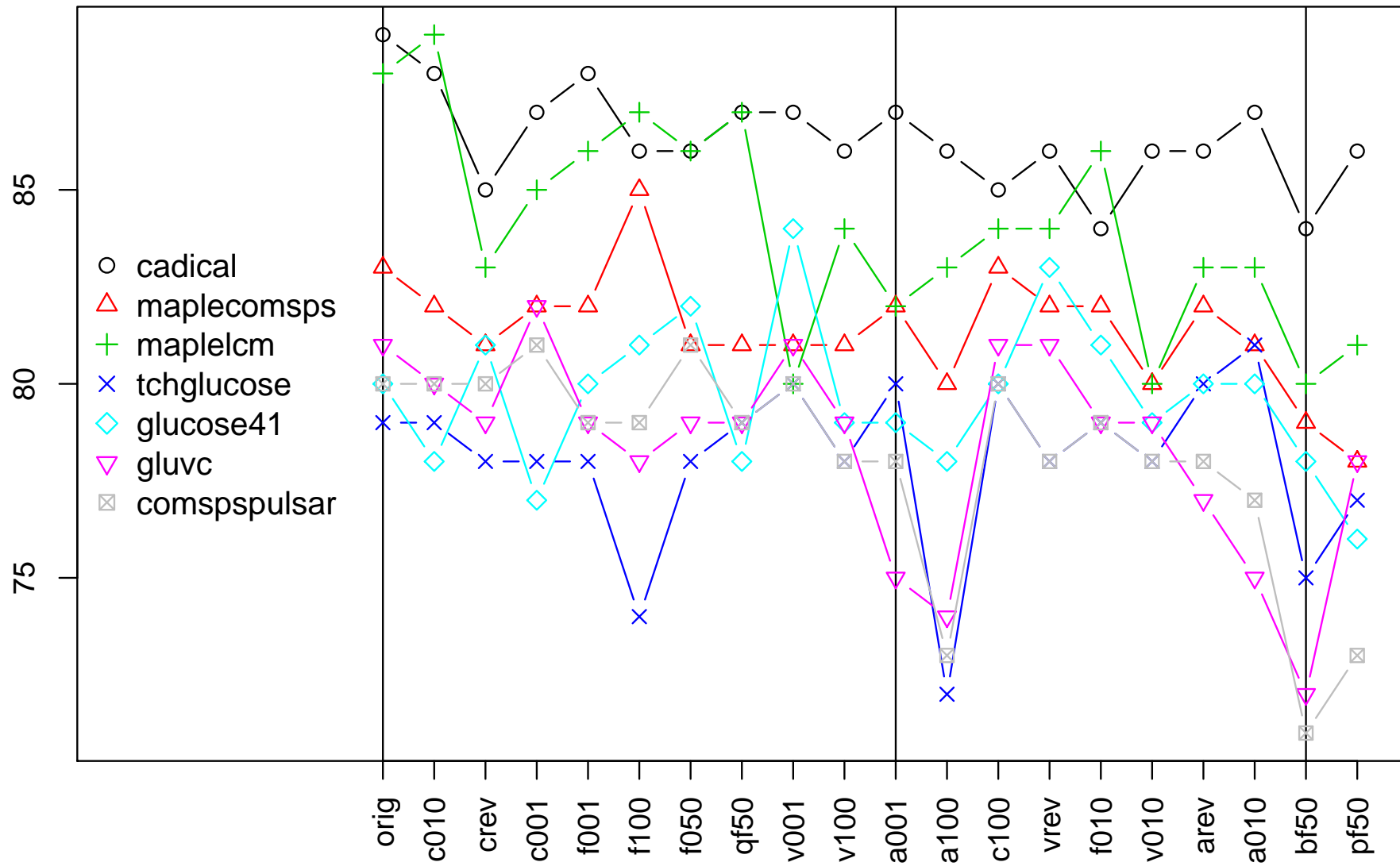
Solved instances application track SAT 2016 competition



Solved satisfiable instances application SAT 2016 competition



Solved unsatisfiable instances application track SAT 2016



Ranking in application track SAT 2016 competition

	par2			solved			sat			unsat		
	<i>o</i>	μ	σ	<i>o</i>	μ	σ	<i>o</i>	μ	σ	<i>o</i>	μ	σ
cadical	1	1.15	0.37	1	1.95	0.83	1	4.95	1.67	1	1.15	0.37
maplecomsps	2	2.30	0.80	3	2.55	0.89	2	1.85	0.99	3	3.10	0.55
maplelcm	3	2.85	0.88	2	1.60	0.68	3	1.90	1.17	2	2.20	1.24
tchglucose	4	4.55	0.94	5	4.85	0.99	4	3.45	1.00	7	5.85	1.09
glucose41	5	5.30	1.42	4	5.30	1.42	5	5.35	1.57	5	4.65	1.35
gluvc	6	6.15	0.59	6	6.10	0.55	7	5.80	1.15	4	5.00	1.26
comspulsar	7	5.70	1.30	7	5.65	1.23	6	4.70	1.72	6	6.05	0.76

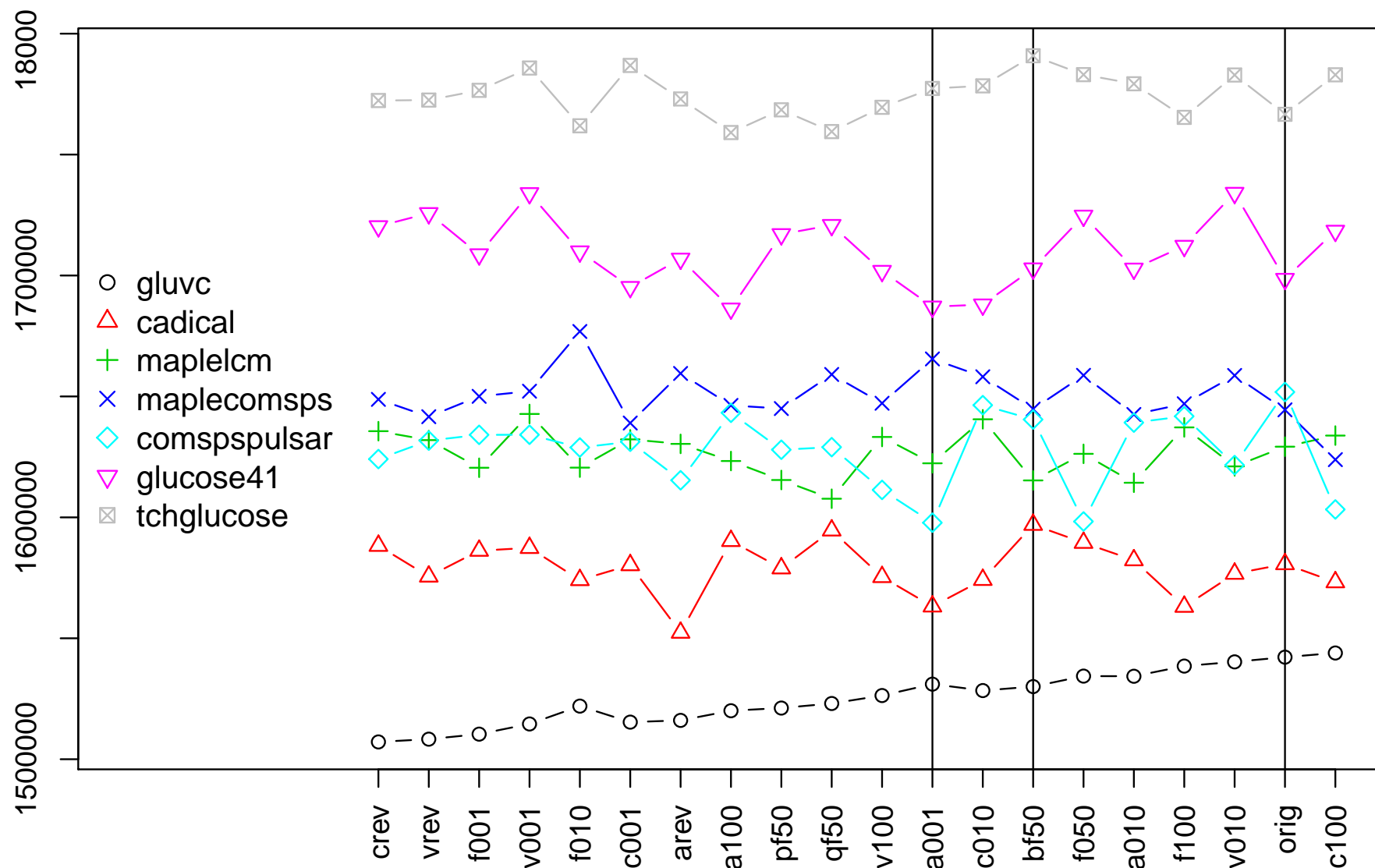
o original μ average σ standard deviation

Scores in application track SAT 2016 competition

	par2			solved			sat			unsat		
	<i>o</i>	μ	σ	<i>o</i>	μ	σ	<i>o</i>	μ	σ	<i>o</i>	μ	σ
cadical	1561368	1643180	37184	154	145.80	3.29	65	59.50	2.67	89	86.30	1.26
maplecomsps	1642508	1670404	28498	147	144.80	2.91	64	63.40	1.88	83	81.40	1.50
maplelcm	1644453	1681871	30163	152	147.10	3.48	64	63.05	2.33	88	84.05	2.68
tchglucose	1686618	1716486	28651	141	138.70	3.29	62	60.65	1.63	79	78.05	2.19
glucose41	1687616	1729213	30800	142	138.05	3.55	62	58.35	2.50	80	79.70	1.98
gluvc	1702788	1738847	27915	141	136.85	2.64	60	58.45	1.36	81	78.40	2.62
comspulsar	1715156	1734357	34491	140	137.45	4.03	60	59.35	2.25	80	78.10	2.73

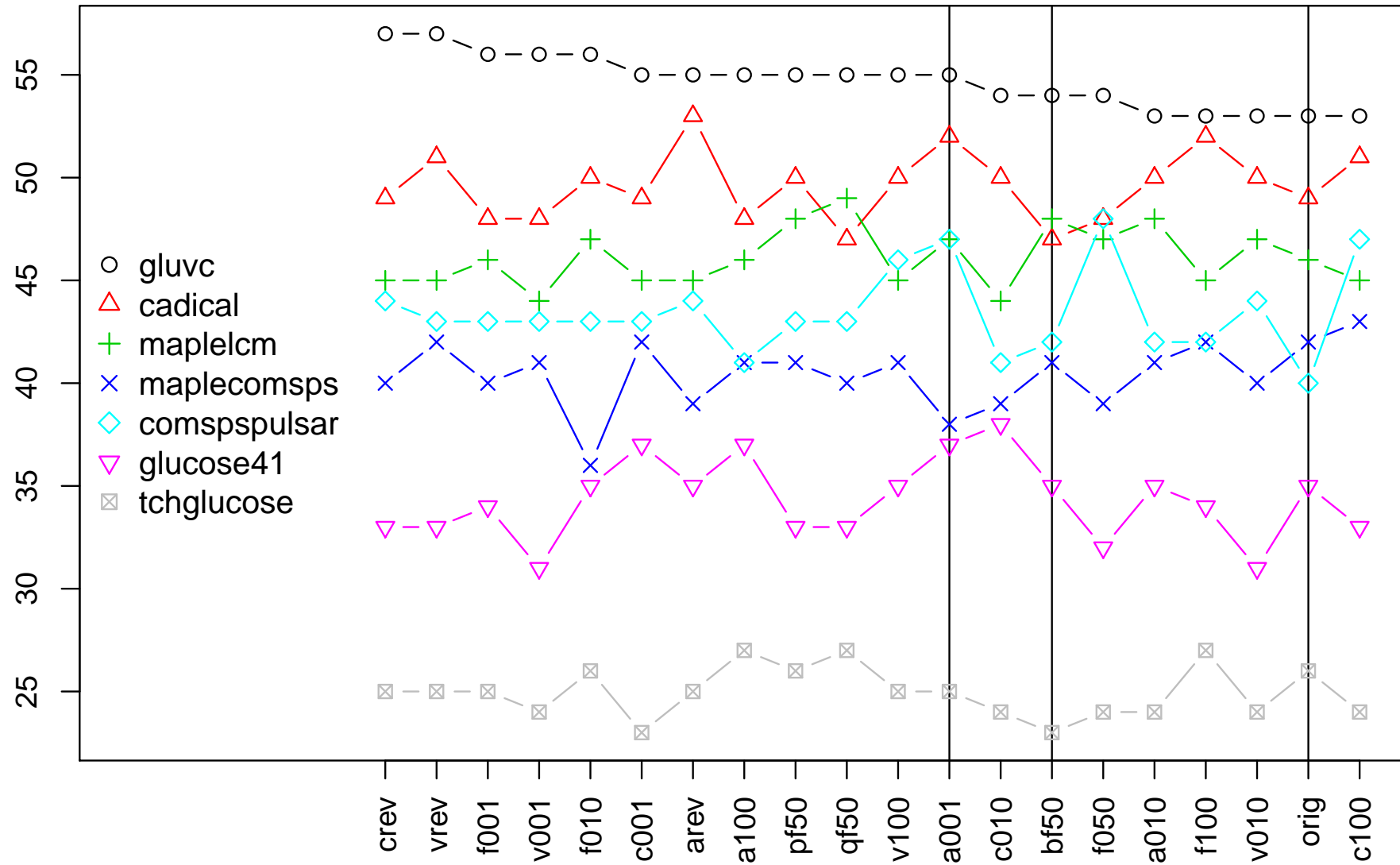
o original μ average σ standard deviation

Par2 score crafted track SAT 2016 competition

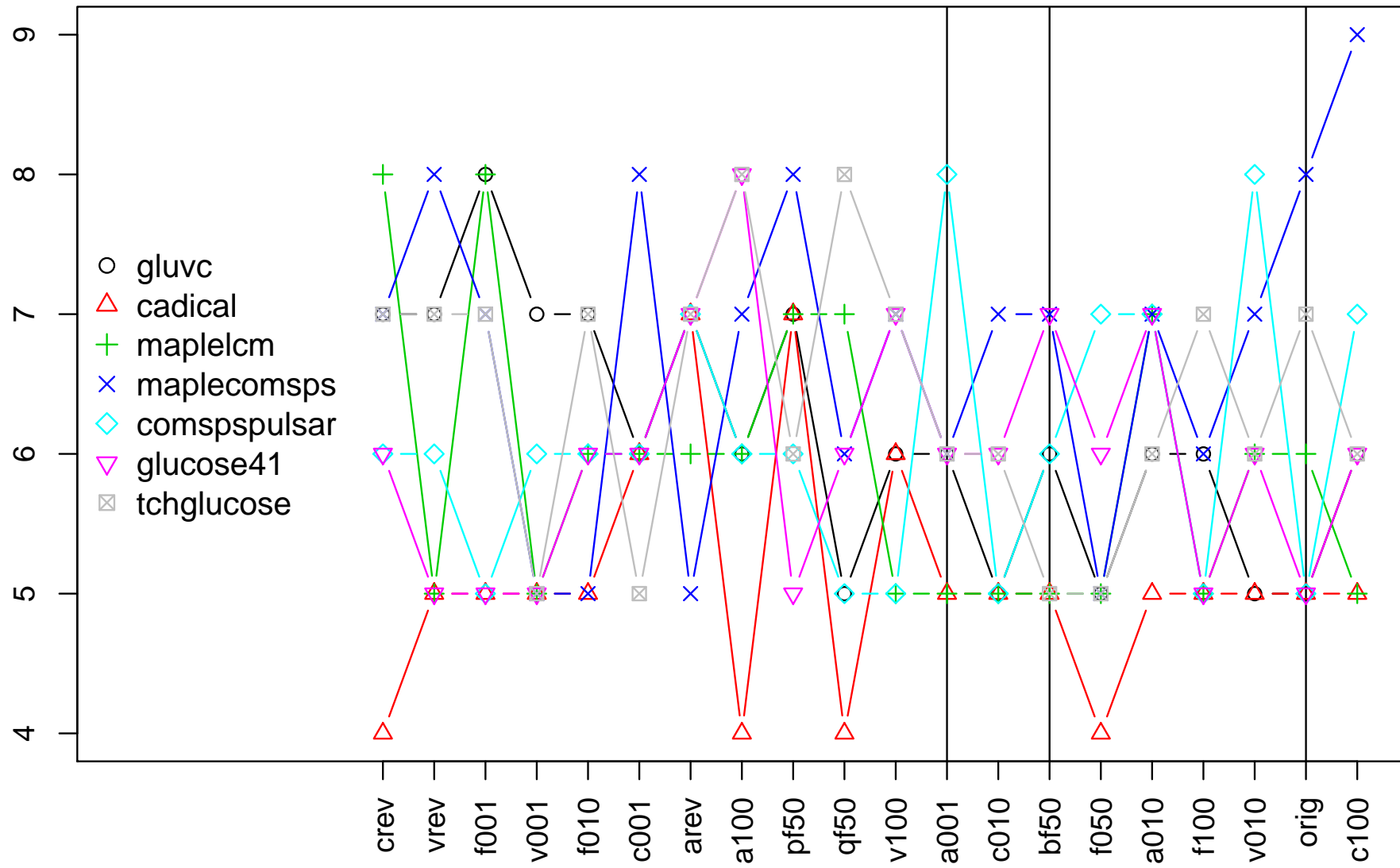


scramblings on x-axis sorted by number of solved instances by "gluvc"

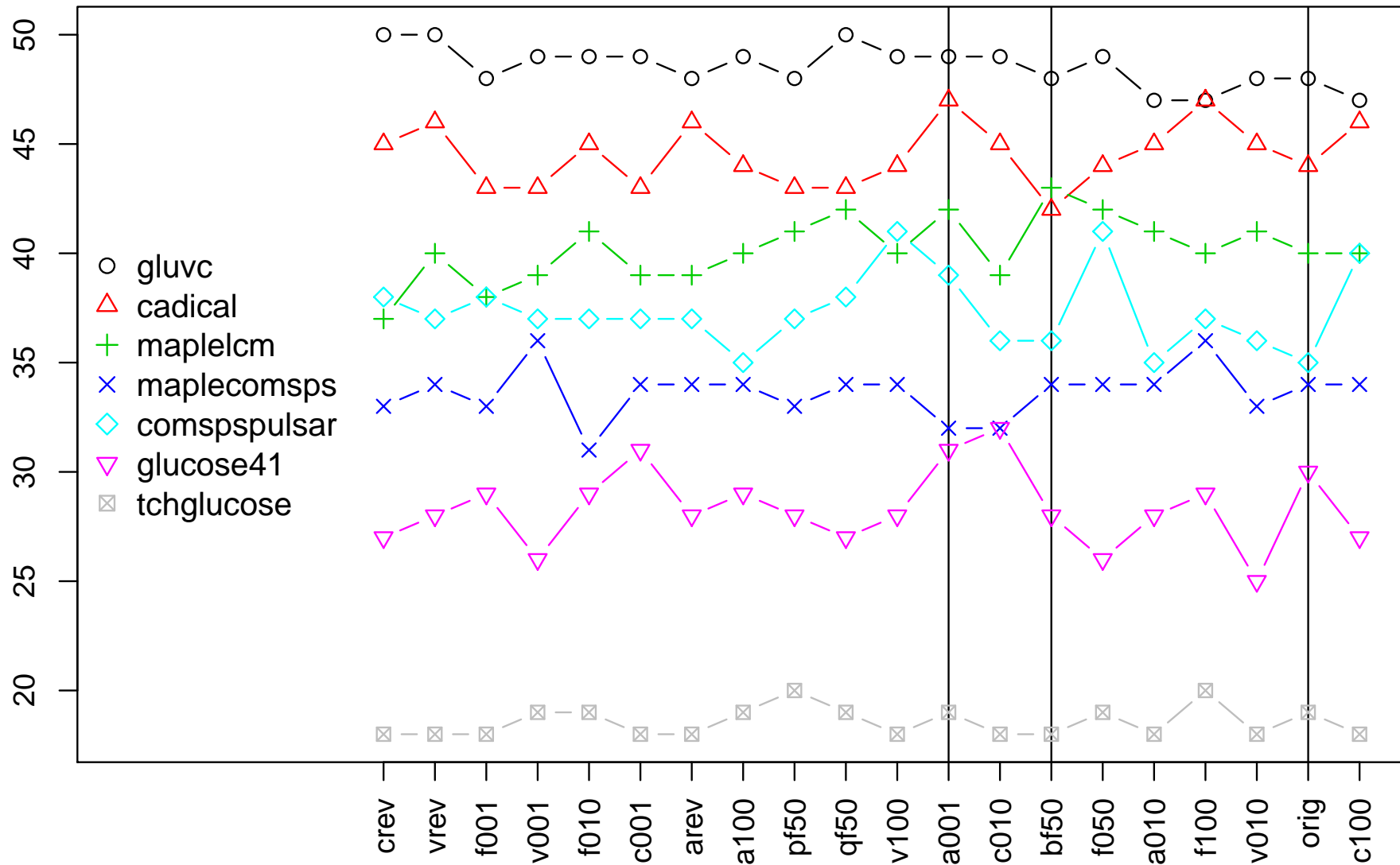
Solved instances crafted track SAT 2016 competition



Solved satisfiable instances crafted track SAT 2016 competition



Solved unsatisfiable instances crafted track SAT 2016 competition



Ranking in crafted track SAT 2016 competition

	par2			solved			sat			unsat		
	<i>o</i>	μ	σ	<i>o</i>	μ	σ	<i>o</i>	μ	σ	<i>o</i>	μ	σ
gluvc	1	1.00	0.00	1	1.00	0.00	7	4.15	2.08	1	1.00	0.00
cadical	2	2.00	0.00	2	2.10	0.31	5	6.00	1.26	2	2.05	0.22
maplelcm	3	3.50	0.61	3	3.10	0.55	3	3.95	1.88	3	3.15	0.49
maplecomsps	4	4.90	0.31	4	4.95	0.22	1	2.50	1.67	5	5.00	0.00
comspspulsar	5	3.60	0.60	5	3.85	0.49	6	3.90	1.77	4	3.80	0.41
glucose41	6	6.00	0.00	6	6.00	0.00	4	4.15	1.69	6	6.00	0.00
tchglucose	7	7.00	0.00	7	7.00	0.00	2	3.35	2.03	7	7.00	0.00

o original μ average σ standard deviation

Scores in crafted track SAT 2016 competition

	par2			solved			sat			unsat		
	<i>o</i>	μ	σ	<i>o</i>	μ	σ	<i>o</i>	μ	σ	<i>o</i>	μ	σ
gluvc	1542210	1525377	11383	53	54.70	1.30	5	6.15	0.88	48	48.55	0.94
cadical	1580688	1579156	11125	49	49.60	1.67	5	5.10	0.85	44	44.50	1.43
maplelcm	1629226	1626691	9516	46	46.10	1.45	6	5.90	1.02	40	40.20	1.47
maplecomsps	1644454	1650459	11235	42	40.40	1.64	8	6.75	1.16	34	33.65	1.18
comspspulsar	1651826	1627593	15569	40	43.45	2.11	5	6.10	0.97	35	37.35	1.79
glucose41	1698562	1709790	14641	35	34.30	1.98	5	6.00	0.86	30	28.30	1.78
tchglucose	1766652	1774629	9319	26	24.95	1.23	7	6.40	0.94	19	18.55	0.69

o original μ average σ standard deviation

Conclusion

<http://fmv.jku.at/scrانfilize>

- `scrانfilize` tool
 - adjustable scrambling of CNF formulas
 - check results to be stable under scrambling
 - check robustness of solver
- extensive experiments
 - 20 scramblings of benchmarks from SAT 2016 and SAT 2017 competition
 - best 7 solvers from SAT 2017 competition
 - 12 years of CPU time
- scrambling not necessary to increase significance of competition results
 - scrambling would not really have changed ranking in SAT 2017 competition
 - scrambling would have slightly changed ranking in SAT 2016 Competition
- we still think current solvers are overtuned on existing benchmarks
- open questions: **Other forms of Scrambling?** **How to select benchmarks?**