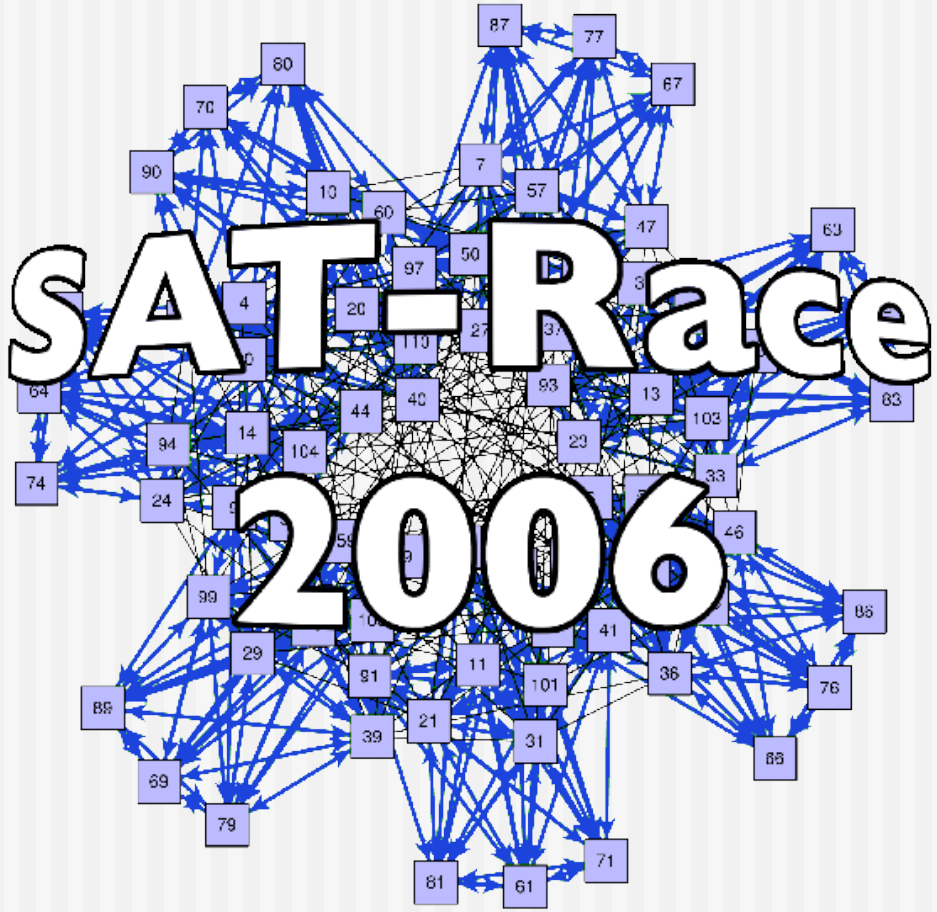


Carsten Sinz · Nina Amla · João Marques Silva
Emmanuel Zarpas · Daniel Le Berre · Laurent Simon

What is SAT-Race?

- „Small SAT-Competition“
  - Only industrial category benchmarks
    (no handcrafted and random)
  - Short run-times
    (15 minutes timeout per instance)
  - Mixture of satisfiable / unsatisfiable instances
    (thus not suitable for local-search solvers)
  - „Black-box“ solvers permitted

Organizers

- **Chair**
  - Carsten Sinz (J. Kepler University Linz, Austria)
- **Advisory Panel**
  - Nina Amla (Cadence Design Systems, USA)
  - João Marques Silva (University of Southampton, UK)
  - Emmanuel Zarpas (IBM Haifa Research Lab, Israel)
- **Technical Consultants**
  - Daniel Le Berre (Université d'Artois, France)
  - Laurent Simon (Université Paris-Sud, France)

Solvers

- Received 29 solvers by 23 submitters from 13 nations

Australia	1 / 1
Austria	4 / 1
Canada	3 / 3
France	3 / 3
Germany	3 / 2
Israel	1 / 1
Japan	1 / 1

Northern Ireland	1 / 1
Portugal	1 / 1
Spain	1 / 1
Sweden	1 / 1
Netherlands	2 / 1
USA	7 / 6

(X / Y: X solvers, Y submitters)

Europe: 16 solvers, North America: 10, Asia/Australia: 2, Middle East: 1

- 3 industrial solvers, 25 academic, 1 private/amateur

Qualification

- Two qualification rounds
  - Each consisting of 50 benchmark instances
  - Increased runtime-threshold of 20 minutes
  - Successful participation in at least one round required to participate in SAT-Race
  - Instances published on the Web in advance
- To ascertain solver correctness and efficiency
- 1st round took place after May 17, 2nd round after June 16

Results Qualification Rounds

- Qualification Round 1:
  - 15 participating solvers
  - 6 solvers already qualified for SAT-Race (by solving more than 40 out of 50 instances):
    Eureka, Rsat, Barcelogic, Actin (minisat+i), Tinisat, zChaff
- Qualification Round 2:
  - 17 participating solvers
  - 13 solvers qualified (3 of them already qualified by QR1):
    Actin (minisat+i), MiniSAT 2.0β, picosat, Cadence-MiniSAT, Rsat, qpicosat, Tinisat, sat4j, qcompsat, compsat, mxc, mucsat, Hsat
- Overall result: 16 (out of 29) solvers qualified
  [9 solvers retracted, 4 showed insufficient performance]

Qualified Solvers

Solver	Author	Affiliation
Actin (minisat+i)	Raihan Kibria	TU Darmstadt
Barcelogic	Robert Nieuwenhuis	TU Catalonia, Barcelona
Cadence MiniSAT	Niklas Een	Cadence Design Systems
CompSAT	Armin Biere	JKU Linz
Eureka	Alexander Nadel	Intel
HyperSAT	Domagoj Babic	UBC
MiniSAT 2.0	Niklas Sörensson	Chalmers
Mucsat	Nicolas Rachinsky	LMU Munich
MXC v.1	David Mitchell	SFU
PicoSAT	Armin Biere	JKU Linz
QCompSAT	Armin Biere	JKU Linz
QPicoSAT	Armin Biere	JKU Linz
Rsat	Thammanit Pipatsrisawat	UCLA
SAT4J	Daniel Le Berre	CRIL-CNRS
TINISAT	Jinbo Huang	NICTA
zChaff 2006	Zhaohui Fu	Princeton

Benchmark Instances

- 20 instances from bounded model checking
  - IBM's benchmark 2002 and 2004 suites
- 40 instances from pipelined machine verification
  - 20 instances from Velev's benchmark suite
  - 20 instances from Manolios' benchmark suite
- 10 instances from cryptanalysis
  - Collision-finding attacks on reduced-round MD5 and SHA0 (Mironov & Zhang)
- 30 instances from former SAT-Competitions (industrial category)
- Up to 889,302 variables, 14,582,074 clauses

Benchmark Selection

- Instances selected at random from benchmark pool
  - “Random” numbers selected by Armin Biere (95), João Marques-Silva (41), and Nina Amla (13), random seed = sum
- Inappropriate instances filtered out
  - too easy: all solvers in <60 sec, one solver in <1 sec
  - too hard: not handled by any solver

Scoring

1. Solution points: 1 point for each instance solved in ≤900 seconds
2. Speed points:

p_{max} = x / #successful_solvers

$p_s = p_{max} \cdot (1 - t_s / T)$

with x set to the maximal value s.t. $p_s \leq 1$ for all solvers and instances

Computing Environment

- Linux-Cluster at Johannes Kepler University Linz
  - 15 compute nodes
  - Pentium 4 @ 3 GHz
  - 2 MB main memory

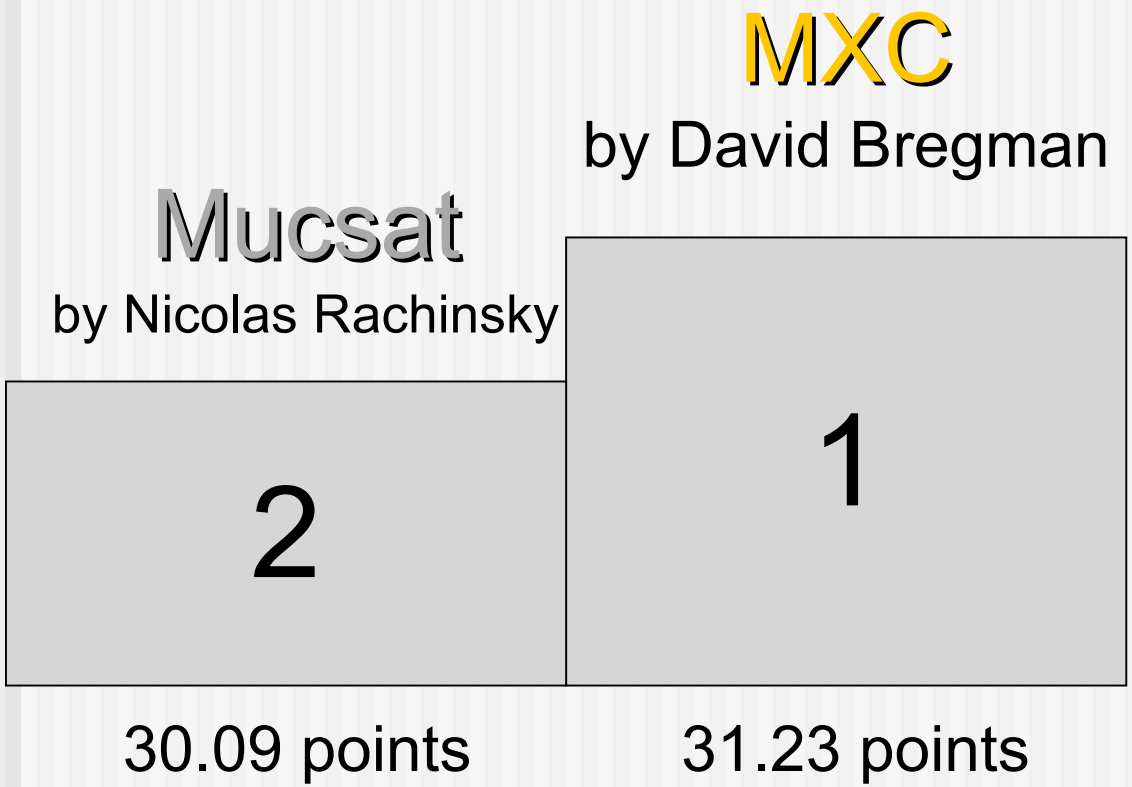
- 16.6 days CPU time for SAT-Race (plus 16.6 days for the qualification rounds)

Results

Winners


Minisat2.0
by Niklas Sörensson
Eureka
by Alexander Nadel
Rsat
by Thammanit Pipatsrisawat
2
1
3
80.87 points
82.71 points
80.45 points
next best solver 69.39 points

Best Student Solvers

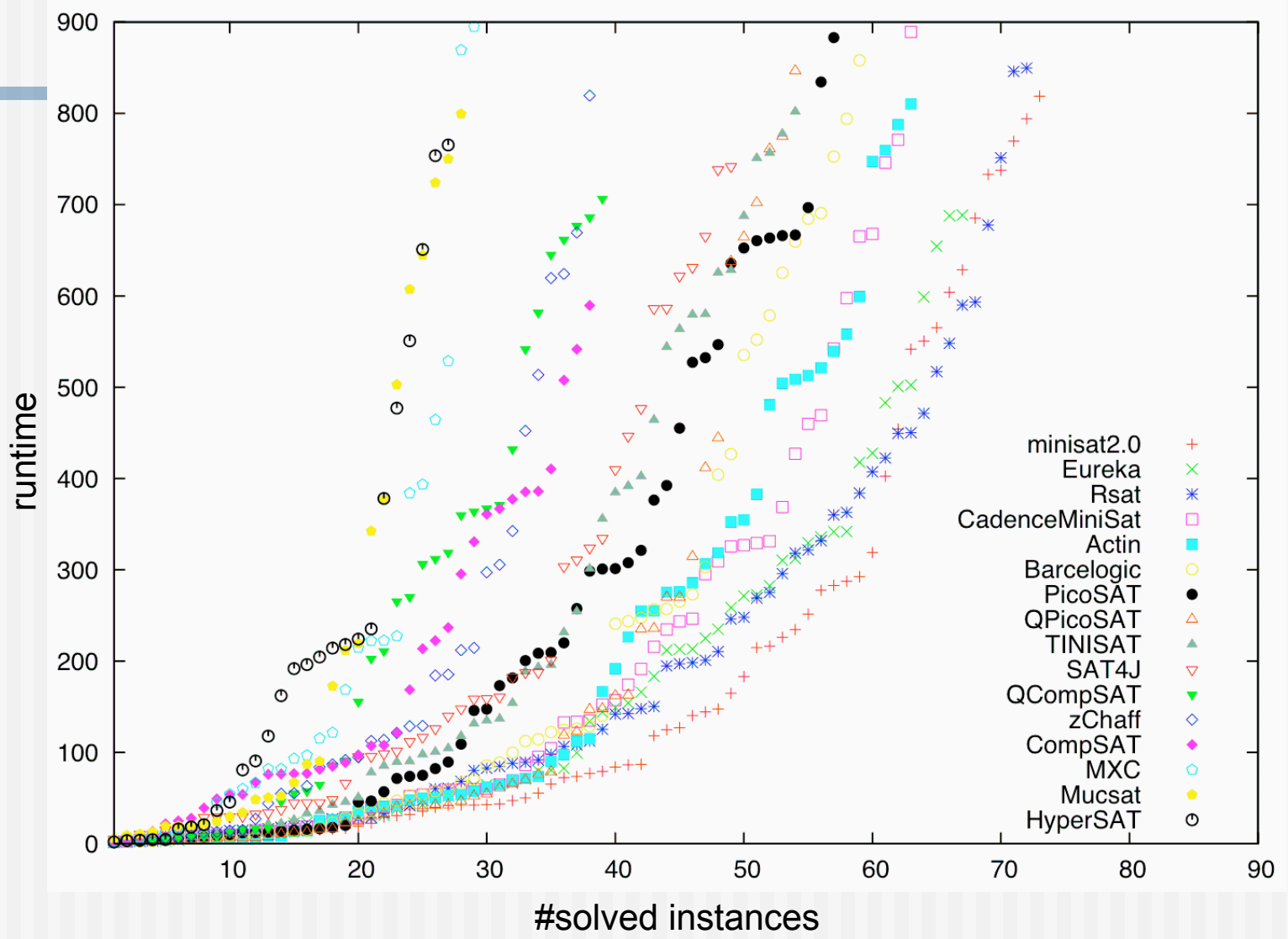


Developed by undergraduate / master students

Complete Ranking

Rank	Solver	Author	Affiliation	#solved	Speed Points	Total Score
1	MiniSAT 2.0	Niklas Sörensson	Chalmers	73	9.71	**82.71**
2	Eureka	Alexander Nadel	Intel	67	13.87	**80.87**
3	Rsat	Thammanit Pipatsrisawat	UCLA	72	8.45	**80.45**
4	Cadence MiniSAT	Niklas Een	Cadence Design Systems	63	6.39	**69.39**
5	Actin (minisat+i)	Raihan Kibria	TU Darmstadt	63	6.29	**69.29**
6	Barcelogic	Robert Nieuwenhuis	TU Catalonia, Barcelona	59	5.98	**64.98**
7	PicoSAT	Armin Biere	JKU Linz	57	5.00	**62.00**
8	QPicoSAT	Armin Biere	JKU Linz	54	5.39	**59.39**
9	TINISAT	Jinbo Huang	NICTA	54	4.91	**58.91**
10	SAT4J	Daniel Le Berre	CRIL-CNRS	49	4.20	**53.20**
11	QCompSAT	Armin Biere	JKU Linz	39	3.22	**42.22**
12	zChaff 2006	Zhaohui Fu	Princeton	38	3.78	**41.78**
13	CompSAT	Armin Biere	JKU Linz	38	3.21	**41.21**
14	MXC v.1	David Mitchell	SFU	29	2.23	**31.23**
15	Mucsat	Nicolas Rachinsky	LMU Munich	28	2.09	**30.09**
16	HyperSAT	Domagoj Babic	UBC	27	2.99	**29.99**

Runtime Comparison



Conclusion

Any progress by SAT-Race?

- ✗ SAT-Race 2006 winner cannot solve more instances than SAT-Competition 2005 winner
- ✓ Nine solvers better than winner of SAT-Competition 2004
- ✓ New ideas for implementation, optimizations
  (Combination of Rsat with SatELite preprocessor can solve 2 more instances than best SAT-Race solver within the given time limit)
- ✓ Many new solvers
  (but mostly slight variants of existing solvers)