# Fourth Pseudo-Boolean Competition PB09

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12th International Conference on
Theory and Applications of Satisfiability Testing,
SAT'09

July 3, 2009

# Outline

- Pseudo-Boolean formalism
- Judges
- Benchmarks and Solvers
- Evaluation Environment
- Results

# Linear Pseudo-Boolean Constraints

- A **linear** pseudo-Boolean constraint may be defined over boolean variables by

$$\sum_i a_i.l_i \geq d \text{ with } a_i, d \in \mathbb{Z}, l_i \in \{x_i, \bar{x}_i\}, x_i \in \mathbb{B}$$

  Example: $3x_1 - 3x_2 + 2\bar{x}_3 + \bar{x}_4 + x_5 \geq 5$
- Extends both clauses and cardinality constraints
  - cardinalities: all $a_i = 1$ and $d > 1$
  - clauses: all $a_i = 1$ and $d = 1$
- PB constraints are more expressive than clauses (one PB constraint may replace an exponential number of clauses)
- A pseudo-Boolean instance is a conjunction of PB constraints

# Non-Linear Pseudo-Boolean Constraints

- A **non-linear** pseudo-Boolean constraint may be defined over boolean variables by

$$\sum_i a_i(\prod_j l_{i,j}) \geq d \text{ with } a_i, d \in \mathbb{Z}, l_{i,j} \in \{x_{i,j}, \bar{x}_{i,j}\}, x_{i,j} \in \mathbb{B}$$

  Example: $3x_1\bar{x}_2 - 3x_2x_4 + 2\bar{x}_3 + \bar{x}_4 + x_5x_6x_7 \geq 5$
- A product is a AND
- Compact encoding for several problems (e.g. factoring problem encoded by one constraint)
- Can be easily translated into linear pseudo-Boolean by introducing new variables and constraints s.t.

$$p \leftrightarrow x_0 \wedge x_1 \wedge \ldots \wedge x_n$$

  (requires 2 PB constraints or n+1 clauses)

# Optimization

- Another difference with SAT is that most PB problems contain a linear cost function to optimize. For example,

$$\text{minimize } f = \sum_i c_i.x_i \text{ with } c_i \in \mathbb{Z}, x_i \in \mathbb{B}$$

- Example of an optimization instance

$$\begin{cases} \text{minimize} & 5x_1 + x_2 + 8x_3 + 2x_4 + 3x_5 \\ \text{subject to} & x_1 + \bar{x}_2 + x_3 \geq 1 \\ & \bar{x}_1 + x_2 + \bar{x}_3 + x_4 \geq 3 \\ & 2\bar{x}_1 + 4x_2 + 2x_3 + x_4 + 5x_5 \geq 5 \\ & 5x_1 + 4x_2 + 6x_3 + x_4 + 3x_5 \geq 10 \end{cases}$$

  Optimum: 8

  $x_1 = x_2 = x_4 = 1$

  $x_3 = x_5 = 0$

- The cost function may contain products (no such instance in the PB09 evaluation)

# Judges

- 2 judges
  - Heidi Dixon (pbChaff solver)
  - Peter Barth (opbdp solver)
- decided of the selection of instances
  all PB07 instances except the reduced ones and all instances submitted this year
- approved the ranking scheme

# Benchmark categories (1)

Based on the objective function

DEC No objective function to optimize (decision problem). The solver must simply find a solution.

OPT An objective function is present. The solver must find a solution with the best possible value of the objective function.

# Benchmark categories (2)

Based on the size of coefficients

SMALLINT small integers: no constraint with a sum of coefficients greater than $2^{20}$ (20 bits)

- Expected to be safe for solvers using 32 bits integers and simple techniques (be careful with learning)
- Strong limit to the encoding of concrete problems.

BIGINT big integers: at least one constraint with a sum of coefficients greater than $2^{20}$ (20 bits)
requires handling of big integers

# Benchmark categories (3)

Based on the linearity of constraints

- **LIN** All constraints are linear
- **NLC** At least one constraint is non linear (contains products of literals)

Additional special category

- **PURE-SAT** All constraints are clauses.

  This is a proper subset of DEC-SMALLINT-LIN

  Contains pigeon-hole instances and some easy instances from the SAT09 competition (which were solved by a majority of solvers in the first phase).

# Categories

- **DEC-SMALLINT-LIN (371 instances)**
- **DEC-SMALLINT-NLC (100 instances)**
- DEC-BIGINT-LIN (14 instances)
- DEC-BIGINT-NLC
- **OPT-SMALLINT-LIN (554 instances)**
- **OPT-SMALLINT-NLC (405 instances)**
- OPT-BIGINT-LIN (452 instances) only 1 solver!
- OPT-BIGINT-NLC
- PURE-SAT (189 instances)

# Submitted solvers

5 teams, 6 solvers

| | |
|---|---|
| BoolVar | Olivier Bailleux<br>no optimization, translation to SAT, see paper SAT09 |
| bsolo | Vasco Manquinho and José Santos<br>3 versions run, one is hors-concours |
| pbclasp | Benjamin Kaufmann |
| SAT4J Pseudo | Daniel Le Berre and Anne Parrain<br>2 versions, handles big integers |
| SCIPclp/spx | Timo Berthold, Stefan Heinz, Marc Pfetsch, and Michael Winkler<br>2 versions, see paper SAT09 |
| wbo | Vasco Manquinho<br>see paper SAT09 |

# Submitted instances

- feature subscription problems (Luis Quesada)
  actually weighted MaxSAT,
  20 instances, OPT-SMALLINT-LIN
- FlexRay scheduling instances (Martin Lukasiewycz)
  special two-dimensional bin packing problem
  9 instances, OPT-SMALLINT-LIN
- optical routing problems (Miroslav Velev)
  70 instances, OPT-BIGINT-LIN

# Evaluation environment

- Cluster of bi-Xeon 3 GHz, 2MB cache, 2GB RAM (all solvers were run in 32 bits mode)
  *kindly provided by the CRIL, University of Artois, France*
  The same environment was used for the SAT competition
- Each solver was given a time limit of 30 minutes (1800s) and a memory limit of 1800 MB (to avoid swapping).
- 157 days of CPU time used

# Verification of results

- The environment performs the following, efficient checks:
  - for SATISFIABLE answers, solvers must output a complete instantiation and the system checks that it satisfies all constraints
  - for UNSATISFIABLE answers, the system only checks that no other solver proved satisfiability
  - for OPTIMUM FOUND answers, the system only checks that no other solver found a better solution
- UNSATISFIABLE and OPTIMUM FOUND answers cannot be completely checked efficiently and therefore should be taken with caution.
- Solvers giving a wrong answer in a category are disqualified in that category.

# Ranking of solvers and Virtual Best Solver (VBS)

Ranking based on two criteria:

1. the number of solved instances
2. ties are broken by considering the cumulated time on solved instances

The Virtual Best Solver (VBS)

- is the virtual solver obtained by combining the best results of all submitted solvers.
- could be obtained by running in parallel all submitted solvers
- represents the current state of the art (SOTA)
- is a reference for the evaluation of the other solvers

# Results for DEC-SMALLINT-LIN

371 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| | *VBS* | 363 | 145 S/218 U | 98% | 100% |
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# Results for DEC-SMALLINT-LIN

371 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| *VBS* | | 363 | 145 S/218 U | 98% | 100% |
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| | | | | | |
| 3 | wbo | 309 | 137 S/172 U | 83% | 85% |
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# Results for DEC-SMALLINT-LIN

371 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| | *VBS* | 363 | 145 S/218 U | 98% | 100% |
| | | | | | |
| 2 | SCIPspx | 310 | 119 S/191 U | 84% | 85% |
| 3 | wbo | 309 | 137 S/172 U | 83% | 85% |

# Results for DEC-SMALLINT-LIN

371 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| *VBS* | | 363 | 145 S/218 U | 98% | 100% |
| 1 | bsolo | 325 | 137 S/188 U | 88% | 90% |
| 2 | SCIPspx | 310 | 119 S/191 U | 84% | 85% |
| 3 | wbo | 309 | 137 S/172 U | 83% | 85% |

# Results for DEC-SMALLINT-LIN

371 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| | *VBS* | 363 | 145 S/218 U | 98% | 100% |
| 1 | bsolo | 325 | 137 S/188 U | 88% | 90% |
| 2 | SCIPspx | 310 | 119 S/191 U | 84% | 85% |
| 3 | wbo | 309 | 137 S/172 U | 83% | 85% |
| 4 | SCIPclp | 308 | 119 S/189 U | 83% | 85% |
| 5 | pbclasp | 300 | 126 S/174 U | 81% | 83% |
| | *bsolo cl (*)* | 290 | 136 S/154 U | 78% | 80% |
| 6 | BoolVar | 288 | 111 S/177 U | 78% | 79% |
| 7 | bsolo pb | 284 | 136 S/148 U | 77% | 78% |
| 8 | SAT4J Resol. | 278 | 106 S/172 U | 75% | 77% |
| 9 | SAT4J CP | 164 | 72 S/92 U | 44% | 45% |

# Results for DEC-SMALLINT-NLC

100 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| | *VBS* | 75 | 55 S/20 U | 75% | 100% |
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# Results for DEC-SMALLINT-NLC

100 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| *VBS* | | 75 | 55 S/20 U | 75% | 100% |
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| 3 | pbclasp | 65 | 50 S/15 U | 65% | 87% |
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# Results for DEC-SMALLINT-NLC

100 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| *VBS* | | 75 | 55 S/20 U | 75% | 100% |
| | | | | | |
| 2 | SCIPspx | 74 | 54 S/20 U | 74% | 99% |
| 3 | pbclasp | 65 | 50 S/15 U | 65% | 87% |

# Results for DEC-SMALLINT-NLC

100 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| *VBS* | | 75 | 55 S/20 U | 75% | 100% |
| 1 | SCIPclp | 74 | 54 S/20 U | 74% | 99% |
| 2 | SCIPspx | 74 | 54 S/20 U | 74% | 99% |
| 3 | pbclasp | 65 | 50 S/15 U | 65% | 87% |

# Results for DEC-SMALLINT-NLC

100 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| | *VBS* | 75 | 55 S/20 U | 75% | 100% |
| 1 | SCIPclp | 74 | 54 S/20 U | 74% | 99% |
| 2 | SCIPspx | 74 | 54 S/20 U | 74% | 99% |
| 3 | pbclasp | 65 | 50 S/15 U | 65% | 87% |
| 4 | SAT4J CP | 65 | 50 S/15 U | 65% | 87% |
| 5 | bsolo pb | 64 | 49 S/15 U | 64% | 85% |
| 6 | SAT4J Resol. | 64 | 51 S/13 U | 64% | 85% |
| 7 | bsolo | 61 | 46 S/15 U | 61% | 81% |
| 8 | wbo | 59 | 44 S/15 U | 59% | 79% |
| 9 | BoolVar | 57 | 42 S/15 U | 57% | 76% |
| | *bsolo cl (*)* | 26 | 16 S/10 U | 26% | 35% |

# Results for OPT-SMALLINT-LIN

554 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| | *VBS* | 343 | 330 O/13 U | 62% | 100% |
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# Results for OPT-SMALLINT-LIN

554 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| *VBS* | | 343 | 330 O/13 U | 62% | 100% |
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| 3 | pbclasp | 188 | 175 O/13 U | 34% | 55% |
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# Results for OPT-SMALLINT-LIN

554 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| *VBS* | | 343 | 330 O/13 U | 62% | 100% |
| | | | | | |
| 2 | bsolo pb | 231 | 218 O/13 U | 42% | 67% |
| | *bsolo cl (*)* | 230 | 217 O/13 U | 42% | 67% |
| 3 | pbclasp | 188 | 175 O/13 U | 34% | 55% |
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# Results for OPT-SMALLINT-LIN

554 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| *VBS* | | 343 | 330 O/13 U | 62% | 100% |
| 1 | SCIPspx | 295 | 282 O/13 U | 53% | 86% |
| 2 | bsolo pb | 231 | 218 O/13 U | 42% | 67% |
| | *bsolo cl (*)* | 230 | 217 O/13 U | 42% | 67% |
| 3 | pbclasp | 188 | 175 O/13 U | 34% | 55% |

# Results for OPT-SMALLINT-LIN

554 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| *VBS* | | 343 | 330 O/13 U | 62% | 100% |
| 1 | SCIPspx | 295 | 282 O/13 U | 53% | 86% |
| 2 | bsolo pb | 231 | 218 O/13 U | 42% | 67% |
| | *bsolo cl (*)* | 230 | 217 O/13 U | 42% | 67% |
| 3 | pbclasp | 188 | 175 O/13 U | 34% | 55% |
| 4 | SAT4J Resol. | 169 | 158 O/11 U | 31% | 49% |
| 5 | SAT4J CP | 140 | 131 O/9 U | 25% | 41% |
| 6 | wbo | 136 | 124 O/12 U | 25% | 40% |

# Results for OPT-SMALLINT-NLC

405 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| | *VBS* | 290 | 290 O | 72% | 100% |
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# Results for OPT-SMALLINT-NLC

405 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| *VBS* | | 290 | 290 O | 72% | 100% |
| | | | | | |
| | | | | | |
| 3 | pbclasp | 263 | 263 O | 65% | 91% |
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# Results for OPT-SMALLINT-NLC

405 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| *VBS* | | 290 | 290 O | 72% | 100% |
| | | | | | |
| 2 | SCIPclp | 286 | 286 O | 71% | 99% |
| 3 | pbclasp | 263 | 263 O | 65% | 91% |
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# Results for OPT-SMALLINT-NLC

405 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| *VBS* | | 290 | 290 O | 72% | 100% |
| 1 | SCIPspx | 289 | 289 O | 71% | 100% |
| 2 | SCIPclp | 286 | 286 O | 71% | 99% |
| 3 | pbclasp | 263 | 263 O | 65% | 91% |
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# Results for OPT-SMALLINT-NLC

405 instances

| Rank | Solver | solved | detail | %inst | %VBS |
|---|---|---|---|---|---|
| | *VBS* | 290 | 290 O | 72% | 100% |
| 1 | SCIPspx | 289 | 289 O | 71% | 100% |
| 2 | SCIPclp | 286 | 286 O | 71% | 99% |
| 3 | pbclasp | 263 | 263 O | 65% | 91% |
| | *bsolo cl (*)* | 232 | 232 O | 57% | 80% |
| 4 | SAT4J Resol. | 226 | 226 O | 56% | 78% |
| 5 | wbo | 223 | 223 O | 55% | 77% |
| 6 | SAT4J CP | 118 | 118 O | 29% | 41% |

# PB09 solvers vs PB07 solvers

- Several solvers of the PB07 evaluation were not submitted this year.
- What if they had been submitted?
- Here's a comparison **on the set of instances common to PB07 and PB09**

# PB09/PB07: DEC-SMALLINT-LIN (371 inst.)

| Rank | Solver | solved | detail |
|---|---|---|---|
| 1 | PB07: Pueblo | 341 | 139 S/202 U |
| 2 | PB07: PBS4_v2 | 327 | 130 S/197 U |
| 3 | PB07: PBS4 | 327 | 130 S/197 U |
| 4 | bsolo | 325 | 137 S/188 U |
| 5 | PB07: PB-clasp | 312 | 137 S/175 U |
| 6 | SCIPspx | 310 | 119 S/191 U |
| 7 | wbo | 309 | 137 S/172 U |
| 8 | SCIPclp | 308 | 119 S/189 U |
| 9 | PB07: minisat+ | 305 | 135 S/170 U |
| 10 | pbclasp | 300 | 126 S/174 U |
| 11 | *bsolo cl (*)* | 290 | 136 S/154 U |
| 12 | BoolVar | 288 | 111 S/177 U |
| .../... | | | |

# PB09/PB07: DEC-SMALLINT-LIN (cont'd)

| Rank | Solver | solved | detail |
|---|---|---|---|
| 13 | bsolo pb | 284 | 136 S/148 U |
| 14 | PB07: PB-clasp | 283 | 112 S/171 U |
| 15 | SAT4J Resol. | 278 | 106 S/172 U |
| 16 | PB07: SAT4JPseudoResol. | 273 | 106 S/167 U |
| 17 | PB07: bsolo 3.0.16 | 271 | 134 S/137 U |
| 18 | PB07: bsolo 3.0.17 | 271 | 134 S/137 U |
| 19 | PB07: glpPB | 200 | 79 S/121 U |
| 20 | SAT4J CP | 164 | 72 S/92 U |
| more PB07 solvers | | | |

# PB09/PB07: DEC-SMALLINT-NLC (100 inst.)

| Rank | Solver | solved | detail |
|---|---|---|---|
| 1 | SCIPclp | 74 | 54 S/20 U |
| 2 | SCIPspx | 74 | 54 S/20 U |
| 3 | pbclasp | 65 | 50 S/15 U |
| 4 | PB07: minisat+ | 65 | 50 S/15 U |
| 5 | PB07: PBS4 | 65 | 50 S/15 U |
| 6 | PB07: PBS4_v2 | 65 | 50 S/15 U |
| 7 | SAT4J CP | 65 | 50 S/15 U |
| 8 | PB07: glpPB | 65 | 45 S/20 U |
| 9 | PB07: PB-clasp | 64 | 49 S/15 U |
| 10 | PB07: Pueblo | 64 | 50 S/14 U |
| 11 | bsolo pb | 64 | 49 S/15 U |
| 12 | SAT4J Resol. | 64 | 51 S/13 U |
| .../... | | | |

# PB09/PB07: DEC-SMALLINT-NLC (cont'd)

| Rank | Solver | solved | detail |
|---|---|---|---|
| 13 | PB07: PB-clasp | 62 | 47 S/15 U |
| 14 | bsolo | 61 | 46 S/15 U |
| 15 | PB07: wildcat-rnp | 60 | 60 S |
| 16 | PB07: wildcat-skc | 60 | 60 S |
| 17 | wbo | 59 | 44 S/15 U |
| 18 | BoolVar | 57 | 42 S/15 U |
| 19 | PB07: oree | 55 | 45 S/10 U |
| 20 | PB07: absconPseudo | 50 | 40 S/10 U |
| 21 | PB07: bsolo 3.0.17 | 28 | 18 S/10 U |
| 22 | PB07: bsolo 3.0.16 | 27 | 17 S/10 U |
| 23 | *bsolo cl (*)* | 26 | 16 S/10 U |

# PB09/PB07: OPT-SMALLINT-LIN (525 inst.)

| Rank | Solver | solved | detail |
|---|---|---|---|
| 1 | SCIPspx | 293 | 280 O/13 U |
| 2 | PB07: bsolo 3.0.17 | 231 | 218 O/13 U |
| 3 | bsolo pb | 215 | 202 O/13 U |
| 4 | *bsolo cl (*)* | 210 | 197 O/13 U |
| 5 | PB07: minisat+ | 201 | 191 O/10 U |
| 6 | PB07: glpPB | 186 | 182 O/4 U |
| 7 | PB07: Pueblo | 179 | 166 O/13 U |
| 8 | pbclasp | 164 | 151 O/13 U |
| 9 | PB07: PB-clasp | 155 | 143 O/12 U |
| 10 | PB07: SAT4JPseudoResol. | 153 | 140 O/13 U |
| 11 | PB07: PB-clasp | 150 | 142 O/8 U |
| 12 | SAT4J Pseudo Resol. | 146 | 135 O/11 U |
| .../... | | | |

# PB09/PB07: OPT-SMALLINT-LIN (cont'd)

| Rank | Solver | solved | detail |
|---|---|---|---|
| 13 | SAT4J Pseudo CP | 140 | 131 O/9 U |
| 14 | PB07: sat4jPseudoCP | 140 | 131 O/9 U |
| 15 | PB07: sat4jPseudoCPClause | 139 | 130 O/9 U |
| 16 | PB07: PBS4_v2 | 137 | 128 O/9 U |
| 17 | PB07: PBS4 | 137 | 128 O/9 U |
| 18 | wbo | 134 | 122 O/12 U |
| more PB07 solvers | | | |

# PB09/PB07: OPT-SMALLINT-NLC (405 inst.)

| Rank | Solver | solved | detail |
|---|---|---|---|
| 1 | SCIPspx | 289 | 289 O |
| 2 | SCIPclp | 286 | 286 O |
| 3 | PB07: minisat+ | 275 | 275 O |
| 4 | pbclasp | 263 | 263 O |
| 5 | PB07: Pueblo | 248 | 248 O |
| 6 | PB07: bsolo 3.0.17 | 239 | 239 O |
| 7 | *bsolo cl (*)* | 232 | 232 O |
| 8 | SAT4J Pseudo Resol. | 226 | 226 O |
| 9 | wbo | 223 | 223 O |
| 10 | PB07: SAT4JPseudoResol. | 216 | 216 O |
| 11 | PB07: PBS4 | 171 | 171 O |
| 12 | PB07: PBS4_v2 | 171 | 171 O |
| 13 | SAT4J Pseudo CP | 118 | 118 O |
| more PB07 solvers | | | |

# Comparing SAT and PB solvers

Since

- PB is an extension of SAT
- the SAT competition and the PB evaluation were run in the same environment
- it's easy to translate a SAT instance in the PB syntax

we may try to compare SAT and PB solvers.

But of course

- PB solvers generally are disadvantaged (must handle coefficients)
- PB solvers may not be optimized for clauses

Context of the comparison

- subset of instances from the CRAFTED and INDUSTRIAL categories which were solved by a majority of solvers in the first phase of the SAT competition
- 20 minutes timeout for all solvers
- all SAT solvers from the Competition or Demonstration division

# PB vs SAT solvers (1/4)

| Rank | Solver | Version | Solved | Time |
|---|---|---|---|---|
| 1 | picosat | 913 | 123 | 8033 |
| 2 | ManySAT 1.1 | aimd 1/2009-03-20 | 122 | 7833 |
| 3 | precosat | 236 | 122 | 10257 |
| 4 | glucose | 1.0 | 121 | 6677 |
| 5 | ManySAT 1.1 | aimd 2/2009-03-20 | 121 | 9567 |
| 6 | MXC | 2009-03-10 | 120 | 7011 |
| 7 | minisat_cumr | p-2009-03-18 | 120 | 9534 |
| 8 | SATzilla2009_I | 2009-03-22 | 120 | 10621 |
| 9 | MiniSat | 2.1 (Sat-race'08 Edition) | 119 | 3883 |
| 10 | Rsat | 2009-03-22 | 119 | 7073 |
| 11 | LySAT | i/2009-03-20 | 119 | 8711 |
| 12 | MiniSAT 09z | 2009-03-22 | 118 | 7843 |
| 13 | ManySAT 1.1 | aimd 0/2009-03-20 | 118 | 8010 |
| 14 | kw | 2009-03-20 | 118 | 8445 |
| 15 | SApperloT | base | 118 | 8738 |

# PB vs SAT solvers (2/4)

| Rank | Solver | Version | Solved | Time |
|---|---|---|---|---|
| 16 | HydraSAT-Flat | 2009-03-22-Flat | 118 | 11389 |
| 17 | clasp | 1.2.0-SAT09-32 | 117 | 5809 |
| 18 | CircUs | 2009-03-23 | 117 | 8522 |
| 19 | LySAT | c/2009-03-20 | 117 | 9182 |
| 20 | HydraSAT | 2009-03-22-Base | 117 | 10614 |
| 21 | VARSAT-industrial | 2009-03-22 | 116 | 11412 |
| 22 | IUT_BMB_SAT | 1.0 | 115 | 10042 |
| 23 | HydraSAT-Multi | 2009-03-22-Multi | 114 | 10582 |
| 24 | pbclasp | 2009-04-24 | 114 | 12758 |
| 25 | SApperloT | hrp | 112 | 9847 |
| 26 | SATzilla2009_C | 2009-03-22 | 108 | 8544 |
| 27 | satake | 2009-03-22 | 105 | 11364 |
| 28 | VARSAT-crafted | 2009-03-22 | 102 | 10986 |
| 29 | SAT4J CORE | 2.1 RC1 | 101 | 14186 |
| 30 | SAT4J Pseudo Resol. | 2.1.1 | 101 | 14920 |

# PB vs SAT solvers (3/4)

| Rank | Solver | Version | Solved | Time |
|---|---|---|---|---|
| 31 | CSat | 2009-03-22 | 99 | 10307 |
| 32 | SATzilla2009_R | 2009-03-22 | 96 | 5676 |
| 33 | wbo | 1.0 | 93 | 13808 |
| 34 | SAT4J Pseudo CP | 2.1.1 | 90 | 15233 |
| 35 | bsolo | 3.1 cl | 86 | 16275 |
| 36 | VARSAT-random | 2009-03-22 | 76 | 12816 |
| 37 | bsolo | 3.1 pb | 74 | 12989 |
| 38 | bsolo | 3.1 | 74 | 14338 |
| 39 | march_hi | hi | 52 | 6503 |
| 40 | march_nn | nn | 52 | 7250 |
| 41 | adaptg2wsat2009 | 2009-03-23 | 50 | 4370 |
| 42 | iPAWS | 2009-03-22 | 48 | 1852 |
| 43 | gnovelty+ | 2009-03-22 | 45 | 3540 |
| 44 | gNovelty+-T | 2009-03-22 | 44 | 4100 |
| 45 | Hybrid2 | 2009-03-22 | 44 | 4605 |

# PB vs SAT solvers (4/4)

| Rank | Solver | Version | Solved | Time |
|---|---|---|---|---|
| 46 | TNM | 2009-03-22 | 44 | 4621 |
| 47 | adaptg2wsat2009++ | 2009-03-23 | 43 | 2136 |
| 48 | hybridGM3 | 3 | 41 | 4388 |
| 49 | hybridGM | 1 | 39 | 1465 |
| 50 | NCVWr | 2009-03-22 | 37 | 6720 |
| 51 | gnovelty+2 | 2009-03-22 | 35 | 2405 |
| 52 | SCIPspx | with SoPLEX | 35 | 5554 |
| 54 | hybridGM7 | 7 | 34 | 1199 |
| 53 | tts | tts-5-0 | 34 | 2906 |
| 55 | slstc | 1.0 | 33 | 3202 |
| 56 | SCIPclp | with CLP | 32 | 3795 |
| 57 | ttsth-5-0 | 2009-03-19 | 32 | 4048 |

# More information

- All details are on the web site
  http://www.cril.univ-artois.fr/PB09
- Thanks to all participants!