Fifth Pseudo-Boolean Competition
PB10

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SAT’10

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Outline

- Pseudo-Boolean constraints
- PBS, PBO, WBO
- Judges
- Benchmarks and Solvers
- Evaluation Environment
- Results
A linear pseudo-Boolean (PB) 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

\[ \sum_i a_i \prod_j l_{i,j} \geq d \] 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 such that

\[ p \leftrightarrow x_0 \land x_1 \land \ldots \land x_n \]

(requires 2 PB constraints or n+1 clauses)
Different problems: PBS, PBO,…

- **PBS (Pseudo Boolean Satisfaction)**
  decide of the satisfiability of a conjunction of PB constraints

- **PBO (Pseudo Boolean Optimization)**
  find a model of a conjunction of PB constraints which optimizes one objective function

\[
\begin{align*}
\text{minimize} & \quad f = \sum_i c_i x_i \quad \text{with } c_i \in \mathbb{Z}, x_i \in \mathbb{B} \\
\text{subject to} & \quad \text{the conjunction of constraints}
\end{align*}
\]
Different problems: ... and WBO

WBO (Weighted Boolean Optimization)

- new in the competition
- generalization of maximum satisfiability for PB constraints
- hard constraints **must** be satisfied
- soft constraints may be violated, but this has a cost
- the cost of an interpretation is the sum of the costs of violated soft constraints
- as in WCSP, there is a top cost. Interpretations with a cost greater or equal to the top cost are non admissible.
- the goal is to find an admissible interpretation with the smallest cost
- **to avoid any intersection with the Max-SAT competition, at least one constraint must not be a clause.**
Judges

- 2 judges (the same as last year)
  - Heidi Dixon (pbChaff solver)
  - Peter Barth (opbdp solver)
- decided of the selection of instances
- suggested a comparison with CPLEX
- approved the results
Benchmark categories (1)

For PBS/PBO, classification 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.

For WBO, classification based on the existence of hard clauses

**SOFT**  No hard clause at all.

**PARTIAL**  At least one hard clause.
Classification 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), but 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 arbitrary precision.

Classification based on the linearity of constraints

**LIN** All constraints are linear

**NLC** At least one constraint is non linear (contains products of literals)
Categories

- DEC-SMALLINT-LIN (452 instances)
- DEC-SMALLINT-NLC (100 instances)
- DEC-BIGINT-LIN
- DEC-BIGINT-NLC
- OPT-SMALLINT-LIN (699 instances)
- OPT-SMALLINT-NLC (409 instances)
- OPT-BIGINT-LIN (532 instances)
- OPT-BIGINT-NLC
- PARTIAL-SMALLINT-LIN (536 instances)
- PARTIAL-BIGINT-LIN (263 instances)
- SOFT-SMALLINT-LIN (201 instances)
- SOFT-BIGINT-LIN (46 instances)
Submitted solvers: (1)

7 teams, 8 solvers, 30 solver versions

Solvers with only PBS/PBO support

- **borg-pb**  Bryan Silverthorn
  a portfolio solver (In Python. Uses clasp, SAT4J and the PB10 versions of bsolo/wbo)

- **bsolo**  Vasco Manquinho and José Santos
  a SAT-like solver with lower bound estimation techniques

- **PBPASSolver**  Amir Aavani
  written in Pascal

- **PB-wave**  Cédric Piette
  a local search solver
Submitted solvers (2)

Solvers with both PBS/PBO and WBO support

**PB/CT** Anders Franzen, Roberto Bruttomesso
based on OpenSMT

**SAT4J Pseudo** Daniel Le Berre and Anne Parrain
3 versions: learn clauses, learn PB constraints, run both in // and exchange intermediate values of the objective function

**SCIP** Stefan Heinz, Marc E. Pfetsch, and Michael Winkler
3 versions: with SoPlex as LP solver, with Clp as LP solver, without any LP solver

**wbo** Vasco Manquinho, Jordi Planes and João Marques-Silva
an unsatisfiability-based solver; iterates over the identification of unsatisfiable subformulas;
An extra solver: pb_cplex

- a direct interface to CPLEX 12.1, a state of the art linear programming solver
- support for PBS/PBO as well as WBO
- written by Vasco Manquinho after a suggestion of the judges
PBS/PBO Instances submitted this year

- resource-constrained project scheduling problem (A. Oliveras)
  converted from the PSPLib
  6216 submitted instances, (4080 DEC-SMALLINT-LIN, 2040 OPT-SMALLINT-LIN)
  80 instances randomly selected in each category

- dependency of packages in a Linux distribution (D. Le Berre)
  converted from the Mancoosi project
  1 DEC-SMALLINT-LIN, 65 OPT-SMALLINT-LIN, 327 OPT-BIGINT-LIN
  at most 80 instances randomly selected in each category

- Tolerant Algebraic Side-Channel Attack (TASCA) on the Keeloq cipher (Y. Oren)
  4 OPT-SMALLINT-NLC
WBO Instances

- no submission at all !!
- generation of WBO from unsatisfiable PBS/PBO instances by adding a random cost between 1 and 100 to
  - 100% of the constraints (only soft constraints)
  - 66% of the constraints (majority of soft constraints)
  - 33% of the constraints (majority of hard constraints)

No top cost imposed in these instances.

- Conversion of WCSP instances
  - 1 hard equality constraint to encode each variable
  - 1 soft constraint to encode the cost of a tuple
Evaluation environment

kindly provided by the CRIL, University of Artois, France
For PBS/PBO: same hardware as last competitions

- Cluster of bi-Xeon 3 GHz, 2MB cache, 2GB RAM
- Each solver was given a time limit of 30 minutes (1800s) and a memory limit of 1800 MB (to avoid swapping).
- 280 days of CPU time used

For WBO: new hardware

- Cluster of bi-Xeon quad-core 2.66 GHz, 8 MB cache, 32 GB RAM
- Each solver was given a time limit of 30 minutes (1800s) and a memory limit of 3800 MB (to avoid swapping).
- 2 solvers per node (limited interactions because of the 2 CPU and the memory limit)
- 90 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, solvers must output a complete instantiation; the system checks if all constraints are satisfied and 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

<table>
<thead>
<tr>
<th>Rank</th>
<th>Solver</th>
<th>#solved</th>
<th>Detail</th>
<th>%inst.</th>
<th>%VBS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Virtual Best Solver (VBS)</td>
<td>434</td>
<td>180 S, 254 U</td>
<td>96%</td>
<td>100%</td>
</tr>
<tr>
<td>1</td>
<td>borg-pb</td>
<td>415</td>
<td>179 S, 236 U</td>
<td>92%</td>
<td>96%</td>
</tr>
<tr>
<td>2</td>
<td>SAT4J Res//CP</td>
<td>382</td>
<td>173 S, 209 U</td>
<td>85%</td>
<td>88%</td>
</tr>
<tr>
<td>3</td>
<td>bsolo 3.2 Card</td>
<td>380</td>
<td>172 S, 208 U</td>
<td>84%</td>
<td>88%</td>
</tr>
<tr>
<td>4</td>
<td>wbo 1.4a</td>
<td>378</td>
<td>171 S, 207 U</td>
<td>84%</td>
<td>87%</td>
</tr>
<tr>
<td>5</td>
<td>PB/CT bugfix</td>
<td>369</td>
<td>164 S, 205 U</td>
<td>82%</td>
<td>85%</td>
</tr>
<tr>
<td>6</td>
<td>SAT4J Res.</td>
<td>367</td>
<td>174 S, 193 U</td>
<td>81%</td>
<td>85%</td>
</tr>
<tr>
<td>7</td>
<td>bsolo 3.2 Cl</td>
<td>355</td>
<td>170 S, 185 U</td>
<td>79%</td>
<td>82%</td>
</tr>
<tr>
<td>8</td>
<td>SCIPspx bugfix</td>
<td>351</td>
<td>139 S, 212 U</td>
<td>78%</td>
<td>81%</td>
</tr>
<tr>
<td>9</td>
<td>SCIPspx</td>
<td>351</td>
<td>141 S, 210 U</td>
<td>78%</td>
<td>81%</td>
</tr>
<tr>
<td>10</td>
<td>SCIPclp</td>
<td>344</td>
<td>144 S, 200 U</td>
<td>76%</td>
<td>79%</td>
</tr>
<tr>
<td>11</td>
<td>pb_cplex</td>
<td>337</td>
<td>155 S, 182 U</td>
<td>75%</td>
<td>78%</td>
</tr>
<tr>
<td>12</td>
<td>SCIPnone</td>
<td>288</td>
<td>154 S, 134 U</td>
<td>64%</td>
<td>66%</td>
</tr>
<tr>
<td>13</td>
<td>SAT4J CP</td>
<td>228</td>
<td>106 S, 122 U</td>
<td>50%</td>
<td>53%</td>
</tr>
<tr>
<td>14</td>
<td>PB-wave</td>
<td>66</td>
<td>66 S</td>
<td>15%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Total number of instances: 452
Time to solve an instance
(SAT/UNSAT answers, category DEC-SMALLINT-LIN)
# Results for DEC-SMALLINT-NLC

<table>
<thead>
<tr>
<th>Rank</th>
<th>Solver</th>
<th>#solved</th>
<th>Detail</th>
<th>%inst.</th>
<th>%VBS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Virtual Best Solver (VBS)</td>
<td>70</td>
<td>50 S, 20 U</td>
<td>70%</td>
<td>100%</td>
</tr>
<tr>
<td>1</td>
<td>pb_cplex</td>
<td>70</td>
<td>50 S, 20 U</td>
<td>70%</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>SCIPspx bugfix</td>
<td>70</td>
<td>50 S, 20 U</td>
<td>70%</td>
<td>100%</td>
</tr>
<tr>
<td>3</td>
<td>SCIPclp</td>
<td>69</td>
<td>50 S, 19 U</td>
<td>69%</td>
<td>99%</td>
</tr>
<tr>
<td>4</td>
<td>SCIPspx</td>
<td>69</td>
<td>50 S, 19 U</td>
<td>69%</td>
<td>99%</td>
</tr>
<tr>
<td>5</td>
<td>SAT4J Res//CP</td>
<td>65</td>
<td>50 S, 15 U</td>
<td>65%</td>
<td>93%</td>
</tr>
<tr>
<td>6</td>
<td>SAT4J CP</td>
<td>65</td>
<td>50 S, 15 U</td>
<td>65%</td>
<td>93%</td>
</tr>
<tr>
<td>7</td>
<td>PB/CT</td>
<td>65</td>
<td>50 S, 15 U</td>
<td>65%</td>
<td>93%</td>
</tr>
<tr>
<td>8</td>
<td>PB/CT bugfix</td>
<td>63</td>
<td>50 S, 13 U</td>
<td>63%</td>
<td>90%</td>
</tr>
<tr>
<td>9</td>
<td>bsolo 3.2 Card</td>
<td>61</td>
<td>46 S, 15 U</td>
<td>61%</td>
<td>87%</td>
</tr>
<tr>
<td>10</td>
<td>wbo 1.4a</td>
<td>57</td>
<td>42 S, 15 U</td>
<td>57%</td>
<td>81%</td>
</tr>
<tr>
<td>11</td>
<td>SCIPnone</td>
<td>49</td>
<td>39 S, 10 U</td>
<td>49%</td>
<td>70%</td>
</tr>
<tr>
<td>12</td>
<td>borg-pb</td>
<td>27</td>
<td>17 S, 10 U</td>
<td>27%</td>
<td>39%</td>
</tr>
<tr>
<td>13</td>
<td>bsolo 3.2 Cl</td>
<td>26</td>
<td>16 S, 10 U</td>
<td>26%</td>
<td>37%</td>
</tr>
<tr>
<td>14</td>
<td>PB-wave</td>
<td>25</td>
<td>25 S</td>
<td>25%</td>
<td>36%</td>
</tr>
<tr>
<td>15</td>
<td>SAT4J Res.</td>
<td>25</td>
<td>10 S, 15 U</td>
<td>25%</td>
<td>36%</td>
</tr>
</tbody>
</table>

Total number of instances: 100
### Results for OPT-SMALLINT-LIN

<table>
<thead>
<tr>
<th>Rank</th>
<th>Solver</th>
<th>#solved</th>
<th>Detail</th>
<th>%inst.</th>
<th>%VBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pb_cplex</td>
<td>417</td>
<td>384 O, 33 U</td>
<td>60%</td>
<td>87%</td>
</tr>
<tr>
<td>2</td>
<td>SCIPspx bugfix</td>
<td>354</td>
<td>321 O, 33 U</td>
<td>51%</td>
<td>74%</td>
</tr>
<tr>
<td>3</td>
<td>bsolo 3.2 Card</td>
<td>333</td>
<td>300 O, 33 U</td>
<td>48%</td>
<td>69%</td>
</tr>
<tr>
<td>4</td>
<td>bsolo 3.2 Cl</td>
<td>328</td>
<td>295 O, 33 U</td>
<td>47%</td>
<td>68%</td>
</tr>
<tr>
<td>5</td>
<td>SCIPclp</td>
<td>319</td>
<td>286 O, 33 U</td>
<td>46%</td>
<td>66%</td>
</tr>
<tr>
<td>6</td>
<td>SCIPspx</td>
<td>317</td>
<td>284 O, 33 U</td>
<td>45%</td>
<td>66%</td>
</tr>
<tr>
<td>7</td>
<td>SAT4J Res//CP</td>
<td>315</td>
<td>282 O, 33 U</td>
<td>45%</td>
<td>65%</td>
</tr>
<tr>
<td>8</td>
<td>SAT4J Res.</td>
<td>303</td>
<td>270 O, 33 U</td>
<td>43%</td>
<td>63%</td>
</tr>
<tr>
<td>9</td>
<td>PB/CT bugfix</td>
<td>283</td>
<td>251 O, 32 U</td>
<td>40%</td>
<td>59%</td>
</tr>
<tr>
<td>10</td>
<td>SAT4J CP</td>
<td>255</td>
<td>226 O, 29 U</td>
<td>36%</td>
<td>53%</td>
</tr>
<tr>
<td>11</td>
<td>SCIPnone</td>
<td>187</td>
<td>158 O, 29 U</td>
<td>27%</td>
<td>39%</td>
</tr>
</tbody>
</table>

Total number of instances: 699
Time to solve an instance
(UNSAT/OPT answers, category OPT-SMALLINT-LIN)

CPU time (s) vs. number of solved instances

- bsole 3.2 Card
- bsole 3.2 Cl
- pb_cplex 2010-06-29
- PB/CT 0.1 fixed
- SAT4J PB CuttingPlan
- SAT4J PB RES // CP 2
- SAT4J PB Resolution
- SCIPclp SCIP 1.2.1.2
- SCIPnone SCIP 1.2.1.
- SCIPspx SCIP 1.2.1.2
- SCIPspx SCIP 1.2.1.3
## Results for OPT-SMALLINT-NLC

<table>
<thead>
<tr>
<th>Rank</th>
<th>Solver</th>
<th>#solved</th>
<th>Detail</th>
<th>%inst.</th>
<th>%VBS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Virtual Best Solver (VBS)</strong></td>
<td>289</td>
<td>289 O</td>
<td>71%</td>
<td>100%</td>
</tr>
<tr>
<td>1</td>
<td>SCIPspx <em>bugfix</em></td>
<td>288</td>
<td>288 O</td>
<td>70%</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>SAT4J Res</td>
<td>271</td>
<td>271 O</td>
<td>66%</td>
<td>94%</td>
</tr>
<tr>
<td>3</td>
<td>SCIPnone</td>
<td>260</td>
<td>260 O</td>
<td>64%</td>
<td>90%</td>
</tr>
<tr>
<td>4</td>
<td>SAT4J Res//CP</td>
<td>250</td>
<td>250 O</td>
<td>61%</td>
<td>87%</td>
</tr>
<tr>
<td>5</td>
<td>bsolo 3.2 Cl</td>
<td>230</td>
<td>230 O</td>
<td>56%</td>
<td>80%</td>
</tr>
<tr>
<td>6</td>
<td>bsolo 3.2 Card</td>
<td>217</td>
<td>217 O</td>
<td>53%</td>
<td>75%</td>
</tr>
<tr>
<td>7</td>
<td>PB/CT</td>
<td>194</td>
<td>194 O</td>
<td>47%</td>
<td>67%</td>
</tr>
<tr>
<td>8</td>
<td>PB/CT <em>bugfix</em></td>
<td>186</td>
<td>186 O</td>
<td>45%</td>
<td>64%</td>
</tr>
<tr>
<td>9</td>
<td>SAT4J CP</td>
<td>117</td>
<td>117 O</td>
<td>29%</td>
<td>40%</td>
</tr>
</tbody>
</table>

*Total number of instances: 409*
Time to solve an instance
(UNSAT/OPT answers, category OPT-SMALLINT-NLC)
## Results for OPT-BIGINT-LIN

<table>
<thead>
<tr>
<th>Rank</th>
<th>Solver</th>
<th>#solved</th>
<th>Detail</th>
<th>%inst.</th>
<th>%VBS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Virtual Best Solver (VBS)</td>
<td>211</td>
<td>152 O, 59 U</td>
<td>40%</td>
<td>100%</td>
</tr>
<tr>
<td>1</td>
<td>SAT4J Res//CP</td>
<td>205</td>
<td>146 O, 59 U</td>
<td>39%</td>
<td>97%</td>
</tr>
<tr>
<td>2</td>
<td>SAT4J Res</td>
<td>198</td>
<td>141 O, 57 U</td>
<td>37%</td>
<td>94%</td>
</tr>
<tr>
<td>3</td>
<td>SAT4J CP</td>
<td>168</td>
<td>110 O, 58 U</td>
<td>32%</td>
<td>80%</td>
</tr>
<tr>
<td>4</td>
<td>PB/CT bugfix</td>
<td>87</td>
<td>53 O, 34 U</td>
<td>16%</td>
<td>41%</td>
</tr>
</tbody>
</table>

*Total number of instances: 532*
Time to solve an instance
(UNSAT/OPT answers, category OPT-BIGINT-LIN)

PB/CT 0.1 fixed
SAT4J PB CuttingPlan
SAT4J PB RES // CP 2
SAT4J PB Resolution

CPU time (s)
number of solved instances
<table>
<thead>
<tr>
<th>Rank</th>
<th>Solver</th>
<th>#solved</th>
<th>Detail</th>
<th>%inst.</th>
<th>%VBS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Virtual Best Solver (VBS)</td>
<td>532</td>
<td>531 O, 1 U</td>
<td>99%</td>
<td>100%</td>
</tr>
<tr>
<td>1</td>
<td>SAT4J Res. bugfix</td>
<td>446</td>
<td>445 O, 1 U</td>
<td>83%</td>
<td>84%</td>
</tr>
<tr>
<td>2</td>
<td>pb_cplex</td>
<td>428</td>
<td>428 O</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>3</td>
<td>PB/CT bugfix</td>
<td>375</td>
<td>374 O, 1 U</td>
<td>70%</td>
<td>70%</td>
</tr>
<tr>
<td>4</td>
<td>wbo 1.4a</td>
<td>373</td>
<td>372 O, 1 U</td>
<td>70%</td>
<td>70%</td>
</tr>
<tr>
<td>5</td>
<td>SCIPclp</td>
<td>297</td>
<td>296 O, 1 U</td>
<td>55%</td>
<td>56%</td>
</tr>
<tr>
<td>6</td>
<td>SCIPclp</td>
<td>282</td>
<td>281 O, 1 U</td>
<td>53%</td>
<td>53%</td>
</tr>
<tr>
<td>7</td>
<td>SCIPspx</td>
<td>269</td>
<td>268 O, 1 U</td>
<td>50%</td>
<td>51%</td>
</tr>
<tr>
<td>8</td>
<td>SCIPnone</td>
<td>146</td>
<td>145 O, 1 U</td>
<td>27%</td>
<td>27%</td>
</tr>
</tbody>
</table>

Total number of instances: 536
Time to solve an instance
(UNSAT/ MOPT answers, category PARTIAL-SMALLINT-LIN)
### Results for SOFT-SMALLINT-LIN

<table>
<thead>
<tr>
<th>Rank</th>
<th>Solver</th>
<th>#solved</th>
<th>Detail</th>
<th>%inst.</th>
<th>%VBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>wbo 1.4a</td>
<td>161</td>
<td>161 O</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>2</td>
<td>pb_cplex</td>
<td>160</td>
<td>160 O</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>3</td>
<td>SAT4J Res. bugfix</td>
<td>160</td>
<td>160 O</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>4</td>
<td>PB/CT bugfix</td>
<td>138</td>
<td>138 O</td>
<td>69%</td>
<td>69%</td>
</tr>
<tr>
<td>5</td>
<td>SCIPclp</td>
<td>113</td>
<td>113 O</td>
<td>56%</td>
<td>56%</td>
</tr>
<tr>
<td>6</td>
<td>SCIPspx</td>
<td>113</td>
<td>113 O</td>
<td>56%</td>
<td>56%</td>
</tr>
<tr>
<td>7</td>
<td>SCIPclp</td>
<td>113</td>
<td>113 O</td>
<td>56%</td>
<td>56%</td>
</tr>
<tr>
<td>8</td>
<td>SCIPnone</td>
<td>22</td>
<td>22 O</td>
<td>11%</td>
<td>11%</td>
</tr>
</tbody>
</table>

**Total number of instances: 201**
Time to solve an instance
(UNSAT/MOPT answers, category SOFT-SMALLINT-LIN)
## Results for PARTIAL-BIGINT-LIN

Total number of instances: 263

<table>
<thead>
<tr>
<th>Rank</th>
<th>Solver</th>
<th>#solved</th>
<th>Detail</th>
<th>%inst.</th>
<th>%VBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Virtual Best Solver (VBS)</td>
<td>135</td>
<td>117 O, 18 U</td>
<td>51%</td>
<td>100%</td>
</tr>
<tr>
<td>1</td>
<td>SAT4J Res. bugfix</td>
<td>113</td>
<td>113 O</td>
<td>43%</td>
<td>84%</td>
</tr>
<tr>
<td>2</td>
<td>PB/CT bugfix</td>
<td>78</td>
<td>78 O</td>
<td>30%</td>
<td>58%</td>
</tr>
</tbody>
</table>
Time to solve an instance
(UNSAT/MOPT answers, category PARTIAL-BIGINT-LIN)

CPU time (s)
number of solved instances

PB/CT 0.1 fixed
SAT4J PB Resolution
A word of warning...

- Keep in mind that the competition only takes a snapshot from a given angle.
- The rankings represent a user point of view, on a specific set of instances. This is only one small part of the picture.
- There are more points of view which are also relevant: innovation, robustness...
Some lessons

- A portfolio approach is valuable
- CPLEX outperforms all other solvers in OPT-SMALLINT-LIN and DEC-SMALLINT-NLC but is not so strong in other categories
- Linear programming techniques can help
- Learning PB constraints has a cost. Alternative approaches are valuable.
More information

- All details are on the web site
  [http://www.cril.univ-artois.fr/PB10](http://www.cril.univ-artois.fr/PB10)
- Get your solvers ready for PB11!
- Thanks to all participants!