Solving (Weighted) Partial MaxSat Through Satisfiability Testing

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Partial MaxSat

$$\begin{array}{ll} C_1 & \\ \ldots & \\ \ldots & \textit{Soft Clauses} \\ \ldots & \\ C_n & \\ C_{n+1} & \\ \ldots & \\ \ldots & \textit{Hard Clauses} \\ \ldots & \\ C_{n+m} & \end{array}$$

Partial MaxSat is the problem of finding an *assignment* to the variables of $\mathcal{C}$ such that no hard clause is falsified and the minimum number of soft clauses are falsified.

Partial MaxSat

$$
\begin{array}{rll}
1: & C_1 & \\
 & \dots & \\
 & \dots & \textit{Soft Clauses} \\
 & \dots & \\
1: & C_{n+1} & \\
\infty: & C_{n+1} & \\
 & \dots & \\
 & \dots & \textit{Hard Clauses} \\
 & \dots & \\
\infty: & C_{n+m} &
\end{array}
$$

Partial MaxSat is the problem of finding an *assignment* to the variables of $\mathcal{C}$ that minimizes the cost of the falsified clauses.

Weighted Partial MaxSat

$$
\begin{array}{rll}
w_1 : & C_1 & \\
 & \ldots & \\
 & \ldots & \textit{Soft Clauses} \\
 & \ldots & \\
w_n : & C_n & \\
\infty : & C_{n+1} & \\
 & \ldots & \\
 & \ldots & \textit{Hard Clauses} \\
 & \ldots & \\
\infty : & C_{n+m} &
\end{array}
$$

Weighted Partial MaxSat is the problem of finding an *assignment* to the variables of $\mathcal{C}$ that minimizes the cost of the falsified clauses.

General approach:

$$
\begin{array}{rll}
1: & C_1 \vee b_1 & \\
 & \dots & \\
 & \dots & \textit{Soft Clauses} \\
 & \dots & \\
1: & C_n \vee b_n & \\
\infty: & C_{n+1} & \\
 & \dots & \\
 & \dots & \textit{Hard Clauses} \\
 & \dots & \\
\infty: & C_{n+m} & \\
\infty: & CNF(\sum b_i \leq k) &
\end{array}
$$

if SAT($k-1$) is unsatisfiable and SAT(k) satisfiable, then k is the optimum.

Solving Weighted Partial MaxSat Through Satisfiability Testing

General approach:

$$
\begin{array}{rll}
w_1 : & C_1 \vee b_1 & \\
 & \dots & \\
 & \dots & \textit{Soft Clauses} \\
 & \dots & \\
w_n : & C_n \vee b_n & \\
\infty : & C_{n+1} & \\
 & \dots & \\
 & \dots & \textit{Hard Clauses} \\
 & \dots & \\
\infty : & C_{n+m} & \\
\infty : & CNF(\sum b_i * w_i \leq k) &
\end{array}
$$

if SAT($k - 1$) is unsatisfiable and SAT(k) satisfiable, then k is the optimum.

MaxSat Solvers Based On Satisfiability Testing

Solvers at MaxSat Evaluation 2008:

- Weighted Partial MaxSat:
  - SAT4Java. D. L. Berre
- Partial MaxSat:
  - Msu1.2. (implementation of FU&MALIK algorithm) J. Marques-Silva, V. Manquinho and J. Planes.
  - Msu4.0. J. Marques-Silva and J. Planes.

Our contribution:

- A Weighted version of the FU&MALIK algorithm (WPM1) together with its proof of correctness
- Another Partial MaxSat algorithm variant of the FU&MALIK algorithm (PM2), and the proof of its correctness

The Fu&Malik algorithm

input: $\varphi = \{C_1, \ldots, C_m\}$	
$cost := 0$	Optimal
while *true* **do**	
$(st, \varphi_c) := SAT(\varphi)$	Call to the SAT solver
if $st = SAT$ **then return** *cost*	
$BV := \emptyset$	Set of blocking variables
for each $C \in \varphi_c$ **do**	
if C is soft **then**	
$b :=$ new blocking variable	
$\varphi := \varphi \setminus \{C\} \cup \{C \vee b\}$	Add blocking variable
$BV := BV \cup \{b\}$	
if $BV = \emptyset$ **then return** UNSAT	No soft clauses in the core
$\varphi := \varphi \cup CNF(\sum_{b \in BV} b = 1)$	Add cardinality as hard clauses
$cost := cost + 1$	

Let φ be a Partial MaxSat Formula, given that φ is unsatisfiable

$$\frac{\varphi}{\dfrac{}{\begin{array}{c}1 : \Box \\ \varphi'\end{array}}}$$

φ and $\varphi' \wedge (1 : \Box)$ are MaxSat equivalent, i.e., the cost of the optimal assignment of φ is equal to the optimal cost of $\varphi' \wedge (1 : \Box)$

FU&MALIK algorithm as Complete Inference

Let φ be a Partial MaxSat Formula, given that φ is unsatisfiable

$$\frac{\varphi}{\dfrac{1 : \square}{\varphi'}}$$

φ and $\varphi' \wedge (1 : \square)$ are MaxSat equivalent, i.e., the cost of the optimal assignment of φ is equal to the optimal cost of $\varphi' \wedge (1 : \square)$

$$\begin{array}{rr} 1 : & x \\ 1 : & \neg x \\ \hline\hline 1 : & \square \\ 1 : & x \vee b_1 \\ 1 : & \neg x \vee b_2 \\ \infty : & b_1 + b_2 = 1 \end{array}$$

Solving Weighted Partial MaxSat with Complete Inference

Let φ be a Weighted Partial MaxSat Formula, given that SAT(φ) is unsatisfiable

$$\frac{\varphi}{\dfrac{}{\begin{array}{c} w : \Box \\ \varphi' \end{array}}}$$

φ and $\varphi' \wedge (w : \Box)$ are MaxSat equivalent

Solving Weighted Partial MaxSat with Complete Inference

Let φ be a Weighted Partial MaxSat Formula, given that SAT(φ) is unsatisfiable

$$\frac{\varphi}{\dfrac{w : \Box}{\varphi'}}$$

φ and $\varphi' \wedge (w : \Box)$ are MaxSat equivalent

$$\begin{array}{rr} 100 : & x \\ 100 : & \neg x \end{array}$$

Solving Weighted Partial MaxSat with Complete Inference

Let φ be a Weighted Partial MaxSat Formula, given that SAT(φ) is unsatisfiable

$$\frac{\varphi}{\begin{array}{c} w : \Box \\ \varphi' \end{array}}$$

φ and $\varphi' \wedge (w : \Box)$ are MaxSat equivalent

$$\frac{\begin{array}{rr} 100 : & x \\ 100 : & \neg x \end{array}}{\begin{array}{rr} 100 : & \Box \\ 100 : & x \vee b_1 \\ 100 : & \neg x \vee b_2 \\ \infty : & b_1 + b_2 = 1 \end{array}}$$

Solving Weighted Partial MaxSat with Complete Inference

Let φ be a Weighted Partial MaxSat Formula, given that SAT(φ) is unsatisfiable

$$\frac{\varphi}{\dfrac{w : \Box}{\varphi'}}$$

φ and $\varphi' \wedge (w : \Box)$ are MaxSat equivalent

$$\begin{array}{rr} 100: & x \\ 100: & \neg x \\ \hline\hline 100: & \Box \\ 100: & x \vee b_1 \\ 100: & \neg x \vee b_2 \\ \infty: & b_1 + b_2 = 1 \end{array} \qquad \begin{array}{rr} 100: & x \\ 200: & \neg x \\ \hline\hline 100: & \Box \\ 100: & x \vee b_1 \\ 100: & \neg x \vee b_2 \\ 100: & \neg x \\ \infty: & b_1 + b_2 = 1 \end{array}$$

The WPM1 algorithm

input: $\varphi = \{(C_1, w_1), \ldots, (C_m, w_m), w_i > 0\}$
cost $:= 0$ — Optimal
while *true* **do**
  $(st, \varphi_c) := SAT(\{C_i \mid (C_i, w_i) \in \varphi\})$ — Call SAT solver without weights
  if $st = SAT$ **then return** *cost*
  $BV := \emptyset$ — Blocking variables of the core
  $w_{min} := \min\{w_i \mid C_i \in \varphi_c \text{ and } C_i \text{ is soft}\}$
  for each $C_i \in \varphi_c$ **do**
    if C_i is soft **then**
      $b_i :=$ new blocking variable
      $\varphi := \varphi \setminus \{(C_i, w_i)\} \cup \{(C_i, w_i - w_{min})\} \cup \{(C_i \vee b_i, w_{min})\}$
      — Duplicate soft clauses
      $BV := BV \cup \{b_i\}$
  if $BV = \emptyset$ **then return** UNSAT — No soft clauses in the core
  else $\varphi := \varphi \cup CNF(\sum_{b \in BV} b = 1)$ — Add cardinality as hard clauses
  $cost := cost + w_{min}$

Example: WPM1

$$
\begin{array}{rr}
1: & x \\
2: & y \\
3: & z \\
\infty: & \neg x \vee \neg y \\
\infty: & x \vee \neg z \\
\infty: & y \vee \neg z
\end{array}
$$

Example: WPM1

$$\begin{array}{rr}
1: & x \\
2: & y \\
3: & z \\
\infty: & \neg x \vee \neg y \\
\infty: & x \vee \neg z \\
\infty: & y \vee \neg z
\end{array}
\qquad
\begin{array}{rr}
3: & \Box \\
1: & x \\
2: & y \\
3: & z \vee b_1 \\
\infty: & \neg x \vee \neg y \\
\infty: & x \vee \neg z \\
\infty: & y \vee \neg z \\
\infty: & b_1 = 1
\end{array}$$

Example: WPM1

$$
\begin{array}{rr}
1: & x \\
2: & y \\
3: & z \\
\infty: & \neg x \vee \neg y \\
\infty: & x \vee \neg z \\
\infty: & y \vee \neg z
\end{array}
\qquad
\begin{array}{rr}
3: & \square \\
1: & x \\
2: & y \\
3: & z \vee b_1 \\
\infty: & \neg x \vee \neg y \\
\infty: & x \vee \neg z \\
\infty: & y \vee \neg z \\
\infty: & b_1 = 1
\end{array}
\qquad
\begin{array}{rr}
4: & \square \\
3: & z \vee b_1 \\
1: & y \\
1: & x \vee b_2 \\
1: & y \vee b_3 \\
\infty: & \neg x \vee \neg y \\
\infty: & x \vee \neg z \\
\infty: & y \vee \neg z \\
\infty: & b_1 = 1 \\
\infty: & b_2 + b_3 = 1
\end{array}
$$

Example: WPM1

Example: WPM1

$$
\begin{aligned}
1 &: & x \\
2 &: & y \\
3 &: & z \\
\infty &: & \neg x \vee \neg y \\
\infty &: & x \vee \neg z \\
\infty &: & y \vee \neg z
\end{aligned}
$$

Example: WPM1

$$\begin{array}{rr} 1: & x \\ 2: & y \\ 3: & z \\ \infty: & \neg x \lor \neg y \\ \infty: & x \lor \neg z \\ \infty: & y \lor \neg z \end{array} \qquad \begin{array}{rr} 1: & \square \\ 2: & y \\ 2: & z \\ 1: & x \lor b_1 \\ 1: & z \lor b_2 \\ \infty: & \neg x \lor \neg y \\ \infty: & x \lor \neg z \\ \infty: & y \lor \neg z \\ \infty: & b_1 + b_2 = 1 \end{array}$$

Example: WPM1

$$
\begin{array}{rr}
1: & x \\
2: & y \\
3: & z \\
\infty: & \neg x \vee \neg y \\
\infty: & x \vee \neg z \\
\infty: & y \vee \neg z
\end{array}
\qquad
\begin{array}{rr}
1: & \square \\
2: & y \\
2: & z \\
1: & x \vee b_1 \\
1: & z \vee b_2 \\
\infty: & \neg x \vee \neg y \\
\infty: & x \vee \neg z \\
\infty: & y \vee \neg z \\
\infty: & b_1 + b_2 = 1
\end{array}
\qquad
\begin{array}{rr}
3: & \square \\
1: & x \vee b_1 \\
1: & z \vee b_2 \\
2: & y \vee b_3 \\
2: & z \vee b_4 \\
\infty: & \neg x \vee \neg y \\
\infty: & x \vee \neg z \\
\infty: & y \vee \neg z \\
\infty: & b_1 + b_2 = 1 \\
\infty: & b_3 + b_4 = 1
\end{array}
$$

Example: WPM1

$$
\begin{array}{rr}
1: & \Box \\
2: & y \\
2: & z \\
1: & x \vee b_1 \\
1: & z \vee b_2 \\
\infty: & \neg x \vee \neg y \\
\infty: & x \vee \neg z \\
\infty: & y \vee \neg z \\
\infty: & b_1 + b_2 = 1
\end{array}
$$

$$
\begin{array}{rr}
3: & \Box \\
1: & x \vee b_1 \\
1: & z \vee b_2 \\
2: & y \vee b_3 \\
2: & z \vee b_4 \\
\infty: & \neg x \vee \neg y \\
\infty: & x \vee \neg z \\
\infty: & y \vee \neg z \\
\infty: & b_1 + b_2 = 1 \\
\infty: & b_3 + b_4 = 1
\end{array}
$$

$$
\begin{array}{rr}
4: & \Box \\
1: & z \vee b_2 \\
1: & y \vee b_3 \\
1: & z \vee b_4 \\
1: & x \vee b_1 \vee b_5 \\
1: & y \vee b_3 \vee b_6 \\
1: & z \vee b_4 \vee b_7 \\
\infty: & \neg x \vee \neg y \\
\infty: & x \vee \neg z \\
\infty: & y \vee \neg z \\
\infty: & b_1 + b_2 = 1 \\
\infty: & b_3 + b_4 = 1 \\
\infty: & b_5 + b_6 + b_7 = 1
\end{array}
$$

The PM2 algorithm

input: $\varphi = \{C_1, \ldots, C_m\}$
$BV := \{b_1, \ldots, b_m\}$ — Set of all blocking variables
$\varphi_w := \{C_1 \vee b_1, \ldots, C_m \vee b_m\}$ — Protect all clauses
$cost := 0$ — Optimal
$L := \emptyset$ — Set of Cores
while *true* **do**
  $(st, \varphi_c) := SAT(\varphi_w \cup CNF(\sum_{b \in BV} b \leq cost))$ — Call to SAT solver with at most cardinality
  if $st = SAT$ **then return** *cost*
  remove the hard clauses from φ_c
  if $\varphi_c = \emptyset$ **then return** UNSAT
  $B := \emptyset$ — Blocking variables of the core
  for each $C = C_i \vee b_i \in \varphi_c$ **do**
    $B := B \cup \{b_i\}$
  $L := L \cup \{\varphi_c\}$
  $k := |\{\psi \in L \mid \psi \subseteq \varphi_c\}|$ — Num. of cores contained in φ_c
  $\varphi_w := \varphi_w \cup CNF(\sum_{b \in B} b \geq k)$ — Add at least cardinality constraint
  $cost := cost + 1$

Example: PM2

$$\begin{array}{rr} 1: & C_1 \vee b_1 \\ 1: & C_2 \vee b_2 \\ 1: & \ldots \\ 1: & C_k \vee b_k \\ 1: & \ldots \\ 1: & C_n \vee b_n \\ \infty: & C_{n+1} \\ \infty: & \ldots \\ \infty: & C_{n+m} \\ \infty: & \sum_1^n b_i \leq 0 \end{array}$$

Example: PM2

$$\begin{array}{rr} 1: & C_1 \vee b_1 \\ 1: & C_2 \vee b_2 \\ 1: & \ldots \\ 1: & C_k \vee b_k \\ 1: & \ldots \\ 1: & C_n \vee b_n \\ \infty: & C_{n+1} \\ \infty: & \ldots \\ \infty: & C_{n+m} \\ \infty: & \sum_1^n b_i \leq 0 \end{array}$$

$$\begin{array}{rr} 1: & \square \\ 1: & C_1 \vee b_1 \\ 1: & C_2 \vee b_2 \\ 1: & \ldots \\ 1: & C_k \vee b_k \\ 1: & \ldots \\ 1: & C_n \vee b_n \\ \infty: & C_{n+1} \\ \infty: & \ldots \\ \infty: & C_{n+m} \\ \infty: & b_1 + b_2 \geq 1 \\ \infty: & \sum_1^n b_i \leq 1 \end{array}$$

Example: PM2

$$
\begin{array}{rr}
1: & C_1 \vee b_1 \\
1: & C_2 \vee b_2 \\
1: & \dots \\
1: & C_k \vee b_k \\
1: & \dots \\
1: & C_n \vee b_n \\
\infty: & C_{n+1} \\
\infty: & \dots \\
\infty: & C_{n+m} \\
\infty: & \sum_1^n b_i \leq 0
\end{array}
\qquad
\begin{array}{rr}
1: & \square \\
1: & C_1 \vee b_1 \\
1: & C_2 \vee b_2 \\
1: & \dots \\
1: & C_k \vee b_k \\
1: & \dots \\
1: & C_n \vee b_n \\
\infty: & C_{n+1} \\
\infty: & \dots \\
\infty: & C_{n+m} \\
\infty: & b_1 + b_2 \geq 1 \\
\infty: & \sum_1^n b_i \leq 1
\end{array}
\qquad
\begin{array}{rr}
2: & \square \\
1: & C_1 \vee b_1 \\
1: & C_2 \vee b_2 \\
1: & \dots \\
1: & C_i \vee b_k \\
1: & \dots \\
1: & C_n \vee b_n \\
\infty: & C_{n+1} \\
\infty: & \dots \\
\infty: & C_{n+m} \\
\infty: & b_1 + b_2 \geq 1 \\
\infty: & \sum_1^k b_i \geq 2 \\
\infty: & \sum_1^n b_i \leq 2
\end{array}
$$

Solvers & Benchmarks

- Our MaxSat solvers: WPM1 and PM2
  - SAT solver: picosat
  - Cardinality constraints: regular encoding for WPM1, sequential counters for PM2.
- Other solvers based on satisfiability Testing: SAT4Java, *msu*1.2 and *msu*4.0.
- Benchmarks: crafted and industrial instances available from the MaxSat Evaluation 2008.

Exp: Unweighted MaxSat Category

set	best08	WPM1	PM2	msu1.2	msu4.0	SAT4J
Crafted						
$\frac{\textit{Maxcut}}{\textit{dimacs\_mod}}$ (62)	**81.8(52)**	0.03(4)	175(7)	0.28(4)	1.71(3)	0.93(2)
$\frac{\textit{Maxcut}}{\textit{random}}$ (58)	**4.5(40)**	-(0)	-(0)	- (0)	- (0)	- (0)
$\frac{\textit{Maxcut}}{\textit{Spinglass}}$ (5)	**1.62(3)**	0.85(2)	102.5(2)	0.68 (2)	-(0)	-(0)
Industrial						
SeanSafarpour(112)	57.5(72)	**66.6(81)**	90.2(75)	57.5(72)	64.4(50)	14.5(10)

Exp: Unweighted MaxSat Category

set	best08	WPM1	PM2.1	msu1.2	msu4.0	SAT4J
Crafted						
Maxcut / dimacs_mod (62)	**81.8(52)**	0.03(4)	72(10)	0.28(4)	1.71(3)	0.93(2)
Maxcut / random (58)	**4.5(40)**	-(0)	-(0)	- (0)	- (0)	- (0)
Maxcut / Spinglass (5)	**1.62(3)**	0.85(2)	4(2)	0.68 (2)	-(0)	-(0)
Industrial						
SeanSafarpour(112)	57.5(72)	**66.6(81)**	60(78)	57.5(72)	64.4(50)	14.5(10)

Exp: Partial MaxSat Category

set	best08	WPM1	PM2	msu1.2	msu4.0	SAT4J
Crafted						
$\frac{Maxclique}{Random}$ (96)	**2.4(96)**	50.4(1)	-(0)	-(0)	106(61)	114(52)
$\frac{Maxclique}{Structured}$ (62)	**73(36)**	41.2(11)	32.6(6)	4.9(7)	105.2(13)	50.5(13)
$\frac{Maxone}{3SAT}$ (80)	**0.46(80)**	16(46)	105.7(79)	52.7(40)	118.2(35)	96.6(31)
$\frac{Maxone}{Structured}$ (60)	**10.1(60)**	0.69(2)	547.5(13)	122.7(2)	3.34(1)	**10.1(60)**
Industrial						
$\frac{Bcp}{fir}$ (59)	49(46)	**32 (57)**	67.4(56)	49.2(46)	-(0)	13.3(10)
$\frac{Bcp}{hipp-yRa1}$ (1183)	19(1111)	3(1122)	**6(1163)**	7.2(1105)	0.29(348)	12.2(1109)
$\frac{Bcp}{msp}$ (148)	**49(104)**	15.5(26)	106(94)	4.9(25)	22.9(79)	8.8(93)
$\frac{Bcp}{mtg}$ (215)	26(206)	5.8(170)	**1.3(215)**	17.5(164)	0.43(22)	57(196)
$\frac{Bcp}{syn}$ (74)	**63(34)**	14.1(32)	**14(38)**	51.1(31)	105.2(11)	67.4(21)
$\frac{Pbo}{mqc-nencdr}$ (128)	**167(115)**	80.4(50)	125(84)	50.3(54)	**167.5(115)**	180.6(102)
$\frac{Pbo}{mqc-nlogencdr}$ (128)	**111(128)**	67.1(75)	130(106)	53(65)	**111(128)**	117.5(126)
$\frac{Pbo}{routing}$ (15)	2.9(15)	**1(15)**	24.7(15)	1.35(15)	54.9(15)	26.4(9)

Exp: Partial MaxSat Category

set	best08	WPM1	PM2.1	msu1.2	msu4.0	SAT4J
Crafted						
$\frac{Maxclique}{Random}$ (96)	**2.4(96)**	50.4(1)	126(54)	-(0)	106(61)	114(52)
$\frac{Maxclique}{Structured}$ (62)	**73(36)**	41.2(11)	62(12)	4.9(7)	105.2(13)	50.5(13)
$\frac{Maxone}{3SAT}$ (80)	**0.46(80)**	16(46)	22(80)	52.7(40)	118.2(35)	96.6(31)
$\frac{Maxone}{Structured}$ (60)	**10.1(60)**	0.69(2)	253(34)	122.7(2)	3.34(1)	**10.1(60)**
Industrial						
$\frac{Bcp}{fir}$ (59)	49(46)	**32 (57)**	18(58)	49.2(46)	-(0)	13.3(10)
$\frac{Bcp}{hipp-yRa1}$ (1183)	19(1111)	3(1122)	**13.5(1163)**	7.2(1105)	0.29(348)	12.2(1109)
$\frac{Bcp}{msp}$ (148)	**49(104)**	15.5(26)	384.2(36)	4.9(25)	22.9(79)	8.8(93)
$\frac{Bcp}{mtg}$ (215)	26(206)	5.8(170)	**10.5(214)**	17.5(164)	0.43(22)	57(196)
$\frac{Bcp}{syn}$ (74)	**63(34)**	14.1(32)	**71.2(34)**	51.1(31)	105.2(11)	67.4(21)
$\frac{Pbo}{mqc-nencdr}$ (128)	**167(115)**	80.4(50)	142(78)	50.3(54)	**167.5(115)**	180.6(102)
$\frac{Pbo}{mqc-nlogencdr}$ (128)	**111(128)**	67.1(75)	140.3(97)	53(65)	**111(128)**	117.5(126)
$\frac{Pbo}{routing}$ (15)	2.9(15)	**1(15)**	24.7(15)	2.9(15)	54.9(15)	26.4(9)

Exp: Weighted (Partial) MaxSat Categories

set	#	best08	WPM1	SAT4J
Weighted MaxSat Category				
Crafted				
KeXu/	15	IncWMaxsatz - **126.5(15)**	478(1)	7.7(4)
Ramsey/	48	lb-psat - **1.63(37)**	0.05(34)	16(35)
WMaxcut/dimacs_mod/	62	ToolBar3 - **59(56)**	0.12(3)	0.84(2)
WMaxcut/Random/	40	MiniMaxSAT - **5.43(40)**	-(0)	-(0)
WMaxcut/Spinglass/	5	MiniMaxSAT - **27.6(4)**	-(0)	-(0)
Weighted Partial MaxSat Category				
Crafted				
Auctions/Auc_paths/	88	IncWMaxsatz - **8.4(88)**	-(0)	497(15)
Auctions/Auc_regions/	88	MiniMaxSAT - **1.7(84)**	-(0)	166(76)
Auctions/Auc_Sched/	84	MiniMaxSAT - **46(84)**	-(0)	317(49)
Random-net/	350	Clone - **72(236)**	194(91)	331(13)
Pseudo-factor/	186	IncWMaxsatz - **0.07(186)**	16(124)	3.3(186)
Pseudo- miplib/	16	**SAT4J - 13(6)**	0.29(3)	**13(6)**
QCP/	25	SAT4J - 6.14(25)	**0.27(25)**	6.14(25)
WCSP/Planning/	71	SAT4J - **6.55(71)**	0.9(46)	**6.55(71)**
WCSP/Spot5/Dir/	21	Clone - 87.6(6)	2.31(4)	76(3)
WCSP/Spot5/Log/	21	Clone - **15(6)**	0.52(5)	63.8(3)
Industrial				
Protein_ins	12	MiniMaxSat - **482(8)**	42(1)	6.05(1)

Thanks!