

Open-WBO @ MaxSAT Evaluation 2023

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I. INTRODUCTION

OPEN-WBO [1] is an open source MaxSAT solver that supports several MaxSAT algorithms [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12] and SAT solvers [13], [14], [15]. OPEN-WBO is particularly efficient for unweighted MaxSAT, and although it is not as competitive in the last years, it was one of the best solvers in the MaxSAT Evaluations from 2014 to 2017. Two versions of OPEN-WBO were submitted to the unweighted track at MaxSAT Evaluation 2023: `open-wbo-oll` [7] and `open-wbo-res` [7], [4], [10]. Both versions use the modified parser with support to the new format where hard clauses are marked with ‘h’ and the ‘p-line’ is removed. The remainder of this document describes the differences between these versions.

II. SAT SOLVERS

OPEN-WBO is based on the data structures of MINISAT 2.2 [13], [16]. Therefore, solvers based on MINISAT 2.2 can be used as a potential back-end solvers. For the MaxSAT Evaluation 2023, we use MERGESAT as the back-end SAT solver of both versions `open-wbo-oll` and `open-wbo-res`.

MERGESAT is a new CDCL solver developed by Norbert Manthey and it is based on the SAT competition winner of 2018, MAPLELCMDISTCHRONOBT [17], and adds several known techniques. For restarts, only partial backtracking is used, learned clause minimization is implemented more efficiently, and also applies simplification again in case the first swipe resulted in a simplification. Finally, the time-based decision heuristic switch is made deterministic by using solving steps. To support being used inside MaxSAT solvers, the incremental search feature had to be enabled again.

III. MAXSAT ALGORITHMS

In this section we briefly describe the algorithms used for the complete and incomplete tracks at the MaxSAT Evaluation 2023.

A. Complete Unweighted Track

Two versions were submitted to the complete unweighted track: `open-wbo-oll` [7] and `open-wbo-res` [7], [4], [10].

`open-wbo-oll` uses the OLL algorithm [7], whereas `open-wbo-res` [7], [4], [10] uses a variant of the unsatisfiability-based algorithm MSU3 [3], [4], [10]. These algorithms work by iteratively refining a lower bound λ on the number of unsatisfied soft clauses until an optimum solution is found. Both

MSU3 and OLL use the Totalizer encoding for incremental MaxSAT solving [4].

More specifically, the `open-wbo-res` version uses the resolution-based partitioning techniques [10] by default. We represent a MaxSAT formula using a resolution-based graph representation and iteratively join partitions by using a proximity measure extracted from the graph representation of the formula. The algorithm ends when only one partition remains, and the optimal solution is found. Since the partitioning of some MaxSAT formulas may be unfeasible or not significant, we heuristically choose to run either MSU3 with partitions or the OLL algorithm. In particular, we do not use partition-based techniques when one of the following criteria is met: (i) the formula is too large ($> 1,000,000$ clauses), (ii) the ratio between the number of partitions and soft clauses is too high (> 0.8), (iii) the sparsity of the graph is too small (< 0.04), or (iv) there exist some at-most-one relations between soft clauses (> 10), i.e., if one soft clause is satisfied it implies that some other soft clauses will be unsatisfied.

B. Preprocessing

We perform identification of unit cores and at-most-one relations between soft clauses by using unit propagation. A similar technique is done in RC2 [18], the winner of the MaxSAT Evaluation 2018.

C. Other

OPEN-WBO now supports printing the certificate in a compact mode using 0’s and 1’s.

IV. AVAILABILITY

The latest release of OPEN-WBO is available under a MIT license in GitHub at <https://github.com/sat-group/open-wbo>.

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REFERENCES

- [1] R. Martins, V. Manquinho, and I. Lynce, “Open-WBO: a Modular MaxSAT Solver,” in *SAT*, ser. LNCS, vol. 8561. Springer, 2014, pp. 438–445.
- [2] V. Manquinho, J. Marques-Silva, and J. Planes, “Algorithms for Weighted Boolean Optimization,” in *SAT*. Springer, 2009, pp. 495–508.
- [3] J. Marques-Silva and J. Planes, “On Using Unsatisfiability for Solving Maximum Satisfiability,” *CoRR*, 2007.
- [4] R. Martins, S. Joshi, V. Manquinho, and I. Lynce, “Incremental Cardinality Constraints for MaxSAT,” in *CP*. Springer, 2014, pp. 531–548.
- [5] R. Martins, V. Manquinho, and I. Lynce, “On Partitioning for Maximum Satisfiability,” in *ECAI*. IOS Press, 2012, pp. 913–914.
- [6] R. Martins, V. M. Manquinho, and I. Lynce, “Community-based partitioning for maxsat solving,” in *SAT*. Springer, 2013, pp. 182–191.
- [7] A. Morgado, C. Dodaro, and J. Marques-Silva, “Core-Guided MaxSAT with Soft Cardinality Constraints,” in *CP*. Springer, 2014, pp. 564–573.
- [8] S. Joshi, R. Martins, and V. M. Manquinho, “Generalized Totalizer Encoding for Pseudo-Boolean Constraints,” in *CP*. Springer, 2015, pp. 200–209.
- [9] R. Martins, V. Manquinho, and I. Lynce, “Improving linear search algorithms with model-based approaches for MaxSAT solving,” *J. Exp. Theor. Artif. Intell.*, vol. 27, no. 5, pp. 673–701, 2015.
- [10] M. Neves, R. Martins, M. Janota, I. Lynce, and V. M. Manquinho, “Exploiting Resolution-Based Representations for MaxSAT Solving,” in *SAT*. Springer, 2015, pp. 272–286.
- [11] S. Joshi, P. Kumar, R. Martins, and S. Rao, “Approximation Strategies for Incomplete MaxSAT,” in *CP*. Springer, 2018.
- [12] S. Joshi, P. Kumar, S. Rao, and R. Martins, “Open-WBO-Inc: Approximation Strategies for Incomplete Weighted MaxSAT,” in *JSAT*. IOS Press, 2019.
- [13] N. Eén and N. Sörensson, “An Extensible SAT-solver,” in *SAT*. Springer, 2003, pp. 502–518.
- [14] G. Audemard and L. Simon, “Predicting Learnt Clauses Quality in Modern SAT Solvers,” in *IJCAI*, 2009, pp. 399–404.
- [15] N. Manthey, “Mergesat,” in *Proceedings of SAT Competition 2019: Solver and Benchmark Descriptions*, 2019.
- [16] N. Sörensson, N. Een, and N. Manthey. (2018, May) GitHub repository for MiniSat. <https://github.com/conp-solutions/minisat>.
- [17] A. Nadel and V. Ryvchin, “Chronological backtracking,” in *SAT*. Springer, 2018, pp. 111–121.
- [18] A. Ignatiev, A. Morgado, and J. Marques-Silva, “PySAT: A Python Toolkit for Prototyping with SAT Oracles,” in *Proc. SAT*, ser. Lecture Notes in Computer Science, O. Beyersdorff and C. M. Wintersteiger, Eds., vol. 10929. Springer, 2018, pp. 428–437.