MiniSat Report

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Abstract. Since time immemorial, logic has helped us make sense of the world that surrounds us, from our ancestors' philosophical inquiries to its use in modern mathematics and informatics. Logic bridges the gap between formal and informal knowledge, proving essential in fields w diverse as databases, programming languages (e.g., Prolog), and propositional logic. This paper focuses on a compelling area within informatics: the Boolean satisfiability problem (SAT), a foundational challenge in computational complexity. SAT asks whether a set of variable assignments can satisfy a Boolean formula and stands as the first problem proven to be NP-complete. Our main focus will be on MiniSat, an SAT solver designed to address this challenge efficiently. For the first time, such solvers enabled tackling practical problems with millions of variables, benefiting both research and industry.
This report includes benchmarks from recent SAT competitions, alongside minor modifications to MiniSat's original code, to compare results and evaluate its performance across different problem instances. With timing data and outputs available on GitHub, this analysis highlights MiniSat's capabilities and underscores the broader impact of SAT solvers in advancing computational problem-solving. The following link holds the contents of the project: https://github.com/AndiSova/VF-Software-Engineering-2024-Project

Keywords: MiniSat · SAT · logic.

1 Introduction

The SAT (Satisfiability) problem, central in computer science and logic, has gained significant traction in recent years as SAT solvers demonstrate their utility across a growing range of applications. From electronic design automation (EDA) to artificial intelligence and optimization, SAT solvers are increasingly leveraged to tackle complex, real-world challenges. Their success is amplified by the ability to encode various problem types into SAT formulations efficiently, allowing for high-speed solutions that can handle industry-specific requirements.

Despite their success, developing or even modifying an SAT solver presents a substantial challenge. Modern SAT solvers incorporate intricate algorithms and optimizations, such as conflict-driven clause learning (CDCL) and non-chronological backtracking, which require expertise in both theory and implementation to be utilized effectively. Although foundational SAT techniques are well-documented, the specific implementation details that enhance solver performance and adaptability often remain obscure or inaccessible to practitioners.

In response to this gap, this report explores the design and implementation of a minimal yet efficient SAT solver, inspired by MINISAT. We focus on providing an accessible path from theoretical concepts to practical code, allowing readers to understand, extend, and apply SAT techniques in various domains. By presenting the structure and methods of a conflict-driven SAT solver, we offer insight into the critical mechanisms that enable fast and flexible problem-solving—unit propagation, clause learning, and constraint management. This report also presents timing results and discusses applications, providing both a theoretical and practical foundation for further exploration of SAT solvers in advanced computational settings.

Ever since 2003, MiniSat has been a helpful hand to the SAT community, providing them with a small, efficient, and readable SAT solver.

1.1 Motivation

Please note that the first paragraph of a section or subsection is not indented. The first paragraph that follows a table, figure, equation etc. does not need an indent, either.

Subsequent paragraphs, however, are indented.

Sample Heading (Third Level) Only two levels of headings should be numbered. Lower level headings remain unnumbered; they are formatted as run-in headings.

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Table 1. Table captions should be placed above the tables.

Heading level	Example	Font size and style
Title (centered)	**Lecture Notes**	14 point, bold
1st-level heading	**1 Introduction**	12 point, bold
2nd-level heading	**2.1 Printing Area**	10 point, bold
3rd-level heading	**Run-in Heading in Bold.** Text follows	10 point, bold
4th-level heading	*Lowest Level Heading.* Text follows	10 point, italic

Displayed equations are centered and set on a separate line.

$$x + y = z \tag{1}$$

Please try to avoid rasterized images for line-art diagrams and schemas. Whenever possible, use vector graphics instead (see Fig. 1).

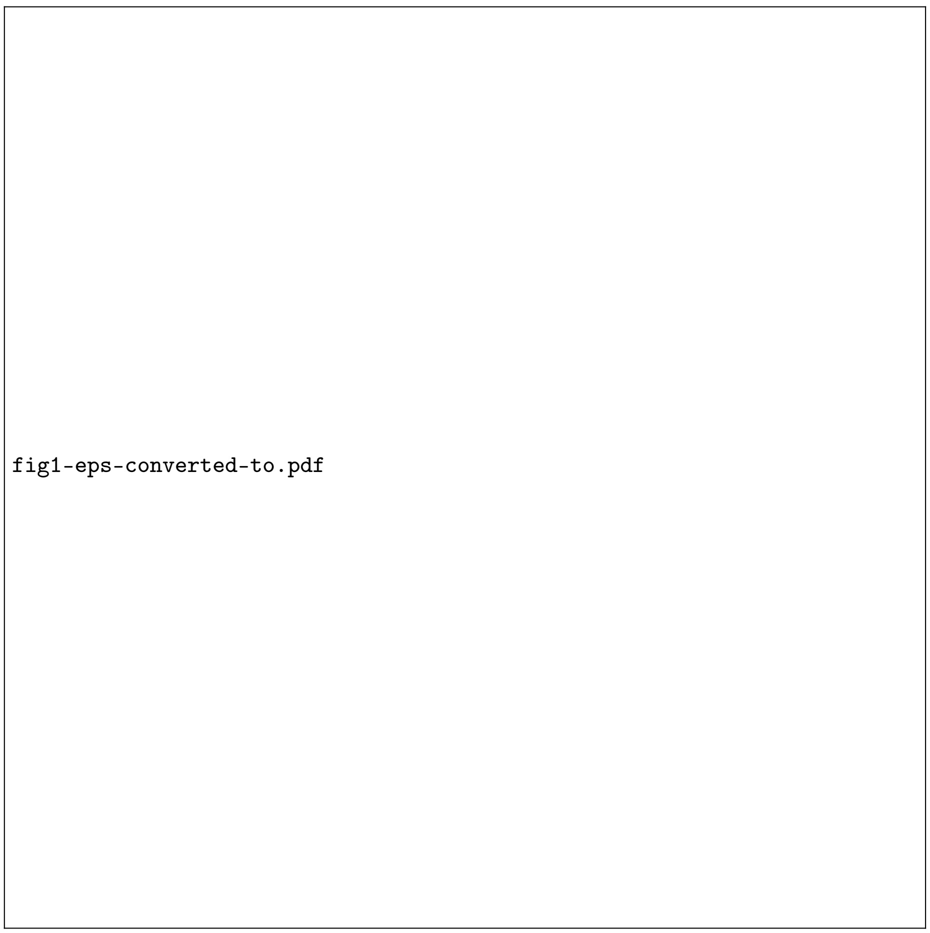

Fig. 1. A figure caption is always placed below the illustration. Please note that short captions are centered, while long ones are justified by the macro package automatically.

Theorem 1. *This is a sample theorem. The run-in heading is set in bold, while the following text appears in italics. Definitions, lemmas, propositions, and corollaries are styled the same way.*

Proof. Proofs, examples, and remarks have the initial word in italics, while the following text appears in normal font.

For citations of references, we prefer the use of square brackets and consecutive numbers. Citations using labels or the author/year convention are also acceptable. The following bibliography provides a sample reference list with entries for journal articles [1], an LNCS chapter [**?**], a book [**?**], proceedings without editors [**?**], and a homepage [**?**]. Multiple citations are grouped [1, **?**,**?**], [1, **?**,**?**,**?**].

Acknowledgments. A bold run-in heading in small font size at the end of the paper is used for general acknowledgments, for example This study was funded by X (grant number Y).

Disclosure of Interests. It is now necessary to declare any competing interests or to specifically state that the authors have no competing interests. Please place the statement with a bold run-in heading in small font size beneath the (optional) acknowledgments[1], for example: The authors have no competing interests to declare that are relevant to the content of this article. Or: Author A has received research grants from Company W. Author B has received a speaker honorarium from Company X and owns stock in Company Y. Author C is a member of committee Z.

[1] If EquinOCS, our proceedings submission system, is used, then the disclaimer can be provided directly in the system.

List of acronyms

References

1. Authors: Niklas Een, Niklas Sorensson; Institute: Chalmers University of Technology, Sweden; Paper title: An Extensible SAT-solver[extended version 1.2]