

## *Review of a Doctoral Thesis at FIT BUT*

**Doctoral thesis** (hereinafter referred to as "thesis"), title of the thesis:

AUTOMATA IN DECISION PROCEDURES AND FORMAL VERIFICATION

**Name of the doctoral student** (hereinafter referred to as "student"), name and surname:

Petr Janků

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**Name and institution of the reviewer** (full name of the reviewer, full name and country of the institution):

Mikoláš Janota, CIIRC, CTU Prague, Czech Republic

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### I. Thesis

#### Appropriateness and relevance

The thesis perfectly fits in the area of formal methods and automated reasoning. It is well-motivated by the urgency of security vulnerabilities of web applications, which are ubiquitous in the nowadays world. The relevancy is also confirmed by high quality publications of the student.

#### A summary of the contributions of the thesis

The thesis is concerned with solving logic formulas containing string constraints, which is a hard but important task for Satisfiability Modulo Theories (SMT) solvers. The task in general is undecidable and the thesis identified several decidable fragments as well as possible over- and under-approximations that enable the use of automata to solve the given constraint.

The contributions are both at the theoretical and practical level. New, more flexible, fragments are defined and shown decidable (chain free, weakly-chaining). New extensions of alternating finite automata are defined, e.g. parametric flat automata (with the objective of handling string-to-number constraints). Numerous other techniques were designed, implemented, and evaluated. The implemented solvers show competitive performance and often better performance than state-of-the-art. Overall, the thesis represents a strong contribution to the field fulfilling its goal.

#### Novelty and significance:

The introduced techniques are both interesting and novel. The SMT area of string constraints is still rather young and it is a hot topic. The techniques have also found their place in this field. Indeed, the POPL article "String constraints with concatenation and transducers solved efficiently" has already accumulated 77 citations on Google Scholar.

#### Evaluation of the formal aspects of the thesis:

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The text of the thesis is written very clearly with good command of English. There are only some minor typographical issues, namely, typesetting of quotation marks (see pgs. 4, 18), lack of non-breaking spaces before citations and abbreviations such as “e.g.”, “i.e.”. The definition of “Dependency graph” appears twice on page 12 and it is not entirely clear if they represent exactly the same concept. While the Parikh image is one of the central topics of the thesis, it is only defined in the Appendix.

### Quality of publications

The student has an excellent publication record at flagship conferences of the field. In particular, POPL and PLDI, which are both CORE A\* conferences.

### II. Student's overall achievements

#### Overall R&D activities evaluation:

During the course of his PhD, the student has produced a number of strong results, which required nontrivial insights into the theory but also was able to develop and implement new concepts leading to stronger automated methods.

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### III. Conclusion

The student demonstrated that he is capable of independent and novel research in the nontrivial area of logic-based solving, SMT, in particular. This have required skills both at the theoretical level but also at technical level. All the presented techniques were implemented in automated tools (SMT solvers). Overall, the quality of the thesis and publications more than fulfils the requirements for a successful PhD thesis.

Prague 23.08.2024

Signature of the reviewer

