Review of Bachelor's Thesis

Student: Pérez Sergio H. Title: Statistical Model Checking of Approximate Computing Systems (id 21362) Sekanina Lukáš, prof. Ing., Ph.D., UPSY FIT VUT **Reviewer:**

1. Assignment complexity

The specification of this thesis is more challenging than a standard specification for undergraduate students. The reason is that it requires deeper knowledge of theoretical topics (such as statistical model checking and timed automata) and advanced software tools (UPPAAL) that are not typically covered by the undergraduate courses.

- 2. **Completeness of assignment requirements** assignment fulfilled The author used UPPAAL for modeling, validation and verification of small circuits that could be used in approximate implementations of digital systems. The specification and all objectives were fulfilled.
- 3. Length of technical report The length of the thesis is as expected.

Presentation level of technical report 4.

The thesis is organized into six chapters that form a logical structure of the text. I would expect more detailed motivation for using statistical model checking for approximate circuit design and analysis.

I would also expect more details about relevant theoretical background, e.g. timed automata and statistics. Without this introduction, it is hard to follow the ideas presented in the thesis even for experts. Review of the approximate computing area is not systematic and could be deeper. For example, the title of page 7 is Approximate systems, but the entire page only deals with approximate memories.

The author selected two case studies (approximate 2-bit multiplier and a small DRAM), created corresponding models for these circuits in UPPAAL and performed various analyses over these models in UPPAAL. In summary, the modeling and experimental parts were performed as expected in this type of projects.

Formal aspects of technical report 5.

The use of English is average, some minor typos can be found quite often. Additional proofreading would definitely increase the quality of the thesis. Unfortunately, the author did not systematically introduce numbering of tables and figures which makes reading of the thesis difficult. In several figures the font size is too small and in some plots (e.g., Fig. 5.1) the description of axes is completely missing. Some terminology and symbols are not defined, e.g. \$\delta\$ (p. 5), SSP test (p. 6), \$\mu\$ (p. 31), \$t 9\$ distribution (p. 31).

6. Literature usage

The author used an unusual referencing system based on round brackets. The list of references covers all relevant areas discussed in the thesis. Instead of URLs, the author should use full references to the original conference or journal papers. For example, a 2-bit approximate multiplier (3) is taken from P. Kulkarni, P. Gupta, and M. D. Ercegovac, "Trading accuracy for power in a multiplier architecture," J. Low Power Electronics, vol. 7, no. 4, pp. 490-501, 2011

Implementation results 7.

The practical result of the thesis is a set of UPPAAL models (DRAM, two multipliers) and graphical plots illustrating various properties of these models. They provide useful information about the circuits under test. It seems, however, that some parameters of these models are not mentioned in the thesis. For example, it is unclear how the time shown in the plots is related to the delay of real circuits.

Utilizability of results 8.

As far as I know this is the first work dealing with statistical model checking in the context of approximate circuit design. This study could be extended and submitted as an original contribution to a relevant scientific conference.

9. **Questions for defence**

- What is the runtime of the proposed approach?
- How does it scale with the operand size of a multiplier?

10. Total assessment

The thesis falls into the research area that I consider as difficult for undergraduate students. The author reported original results in statistical model checking for approximate circuits. Despite of all the aforementioned formal

more demanding assignment

60 p. (D)

85 p. (B)

60 p. (D)

75 p. good (C)

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problems the author did a good job in modeling of behavior of approximate circuits. The proposed approach could enrich existing portfolio of approximate circuit analysis methodologies, especially if it were applied to more complex circuits.

In Brno 29. May 2019

<u>Sekanina Lukáš, prof. Ing., Ph.D.</u> reviewer