Supervisor's Opinion on the PhD Thesis of

Hana Pluháčková

The PhD thesis of Hana Pluháčková concentrates on *automated testing and dynamic analysis of concurrent programs*. Due to massive support of concurrency by current hardware, concurrent software is very common. Writing concurrent code is, however, much more challenging than writing sequential code due to a need to properly synchronize many concurrently running activities. Improper synchronisation may yield rarely appearing, hard to find, yet often deadly errors. Finding such errors by naïve testing is often virtually impossible since they can manifest in just one out of very many runs. Heavy-weight formal verification approaches are in theory capable of finding such bugs, but, despite a lot of progress, they still cannot scale to large software products and are more suitable for thorough verification of critical software. Light-weight static analysis approaches are more scalable and can be highly useful on general-purpose software, but they often suffer from both false positives and false negatives. Alternatively, one can then use (or combine with the above approaches) advanced extrapolating dynamic analyses and/or techniques increasing coverage of concurrent behaviour during testing such as *noise-based testing*, which Hana Pluháčková was considering in her thesis.

Noise-based testing is one of the most light-weight and hence most scalable approaches to testing concurrent programs. However, it also comes with some problems, one of which is the so-called *test and noise configuration setting (TNCS) problem*. This problem consists in that both programs under test as well as the noise-generating systems are usually heavily parameterised and finding the right settings for the most efficient testing is not easy despite some previous attempts to resolve it. It is this problem that the thesis of Hana Pluháčková mostly concentrates on and whose improved solution can significantly contribute to improved possibilities of testing of concurrent programs. I hence find the subject area of the thesis of Hana Pluháčková highly up to date.

The research of Hana Pluháčková was conducted within the VeriFIT research group at the Faculty of Information Technology of Brno University of Technology. At the beginning, Hana was co-supervised by Dr. Zdeněk Letko who then, however, left the faculty. Still, the cooperation with Zdeněk played an important role in the research of Hana. Moreover, during her research, Hana has collaborated in an intense way with several Israeli researchers, including especially Dr. Shmuel Ur, one of the inventors of the original ideas behind noise-based testing, a former IBM Master Inventor, and a co-author of the IBM's ConTest tool that was used in many of the experiments in the thesis.

The research conducted by Hana was an important part of multiple research projects including the Czech-Israeli CONTACT-II project LH13265 "Intelligent Testing and Analysis of Concurrent Software", the European "Runtime Verification beyond Monitoring" (ARVI) COST action IC1402, the GA17-12465S project of the Czech Science Foundation "ROBUST: Verification and Bug Hunting for Advanced Software", as well as the H2020 ECSEL project "AQUAS: Aggregated Quality Assurance for Systems". Moreover, it was also a part of several institutional projects at FIT BUT, including the IT4I Centre of Excellence.

From my point of view, the main contributions of the research of Hana Pluháčková presented in her thesis include:

- A proposal how to apply *multi-objective genetic optimisation* for solving the TNCS problem alongside with various ways how to use statistical techniques to *suppress effects of non-deterministic thread scheduling* on the proposed approach.
- A proposal of using *data mining*, in particular, the *AdaBoost approach* as an alternative to genetic algorithms for solving the TNCS problem. Later on, Hana has also showed how to *combine genetic algorithms and data mining* to exploit their complementary strengths and obtain an even better approach.
- Identification of correlations between coverage values of various coverage metrics used in concurrency testing and an approach based on *finding suitable test and noise settings while experimenting with metrics cheaper to collect*, followed by *final testing under more expensive metrics* (or their combinations).

The results of Hana were published in the proceedings of three conferences and workshops (SSBSE'14, MEMICS'14, and EUROCAST'17), two of which have proceedings published by Springer in the LNCS series, and in one impacted journal, namely, Concurrency and Computation: Practice and Experience, published by Wiley. Moreover, based on the above journal publication, Hana was invited to make a presentation of the results at the European Conference on Data Analysis (ECDA) organised in Paderborn in 2018. The publications have so far attracted eight citations (without self-citations). Despite all the publications have multiple co-authors, I can acknowledge that Hana played a major role on all of them: namely, she contributed some of the main ideas, participated on the writing, and performed most of the implementation and experiments.

As a side note, let me add that, despite Hana has been working outside of the faculty for a while now, she still cooperates with the VeriFIT group, mainly in the area of performance testing and dynamic analysis where she further applies her knowledge of statistics.

To sum up, within her PhD studies, Hana Pluháčková has proved to be creative and to be capable of working independently, systematically, and hard. She has also showed to be able to work on collaborative research projects and to cooperate with foreign researchers. In my opinion, the thesis of Hana Pluháčková satisfies requirements usually associated with PhD theses in the area of computer science and therefore I recommend it to be accepted.

Brno, October 29, 2019 Prof. Tomáš Vojnar