Subject: Ph.D./Dissertation Thesis Review

I made this review upon a request from the Czech Technical University in Prague, Faculty of Information Technology, Department of Digital Design. The request originated from the document with the reference number 366/17/18924, dated on October 10, 2017. The subject of the requested review was an article by Ing. Pavel Vit, entitled “Dependable design methods for programmable circuits with respect to area overhead.” I structured my review, according to the request, as follows:

1. Up-to-dateness of the dissertation: Despite the problem is defined weakly in the thesis, it is evident that it needs recent solutions. Each of them must react to technological progress, evolution of FPGA devices and many other phenomena. Moreover, the problem is strongly application-specific and it cannot be solved in general, abstracting from a particular application or its class. The problem is constantly being solved by various authors/teams worldwide and new approaches to its solution are highly appreciated in both academia and industry. From that viewpoint, the thesis is up to date.

2. Formal structure and organization of the dissertation: At a glance, the thesis seems to be well structured/organized. However, more careful reading of the thesis reveals many formal shortcomings making it very difficult to read. Firstly, the thesis is difficult to read due to many i) language errors, ii) symbols/terms used before they are defined and iii) abstruse sentences. Then, the thesis misses a solid introduction, illustrations/examples and references to many key terms the thesis relies on (for example, to dependability/faults, probability theory, statistics or Markov models). Lastly, some questions remain unanswered after reading the thesis and the reasons for some assertions are not given in the thesis.

3. Completion of the dissertation objectives: The objectives listed in the section 1.3 of the thesis have been completed. However, despite the problem is weakly introduced in the section 1.2, no hypothesis and research questions are explicitly stated in the thesis. So, it is questionable i) on what research questions had the objectives to help answer and ii) what hypothesis should (or should not) be supported/proven by the objectives.

4. Assessment of the methods used in the dissertation: Chosen methods and instruments are appropriate to reach the objectives specified in the thesis. The methods and instruments include:
   (a) An analysis of effects of a technological/decomposition process to properties regarding particular designs (chapter 3). The analysis builds on the following instruments used to quantify the properties: i) FPGAs (Spartan 3E, Virtex V) from Xilinx and the Xilinx ISE tool, ii) ESPRESSO, BOOM and Synplify.
   (b) A proposal of the Upgraded Modified Duplex System (UMDS) architecture/models (chapter 4), driven by the goal of achieving better properties comparing to alternative approaches. The proposal builds mainly on instruments of i) a fine-grained reconfiguration and an error detection/correction, ii) a post-reconfiguration synchronization and iii) Markov models.
   (c) An analysis of properties of the UMDS approach variants, each applied to a practical case study (railway station) and compared to non-UMDS approaches (chapter 5). The analysis builds mainly on instruments of the Fault Tree Analysis (FTA) method, the main goal of which is to quantify Lambda (λ) for a particular approach.

5. Evaluation of the results and contributions of the dissertation: Conclusions made in the thesis are supported by appropriate results. However, as the results apply to a very limited set of platforms and designs, it is questionable whether a general conclusion can be made based on the results. Moreover, the results have not been critically interpreted and relevant knowledge in the field has not been included to a sufficient extent in the interpretation.
6. Remarks, objections, notes, and questions for the defense:

(a) Remarks, objections, notes (what could be clarified in the thesis, but it is not)
In the thesis, it is not clear what is meant, for example, by “Faults caused by SEUs are classified as soft errors” (Abstract, p. iii). “Duplication means system, where two parts perform similar function.” (p. 14), “The simulation process took a lot of time.” (p. 26), “Repaired” in Fig. 4.3 (p. 33), “safety calculation” in Sec. 4.6 (p. 35), “big resistors” (p. 53)? In sect. 2.1 (p. 5), it is stated “Most of these FPGAs are based on SRAM memories”, but not supported by data. It is confusing why there is no voter in Fig. 5.7 (p. 49). Precise definitions of basic dependability attributes and their measures (for example, reliability, failure/hazard rate, MTBF, MTTF, MTTR) are missing in the thesis.

(b) Questions/uncertainties which should be answered/clarified during the defense
i. Explain a) how you meant “Permanent fault is a malfunction of a component to the repairation” (p. 7), b) “Intermittent fault is a periodical malfunction of a component.” (p. 7) and c) what is the fundamental difference between a “transient” and “intermittent” fault?
ii. Characterize i) the properties “Fault Security (FS)”, “Self-Testing (ST)” and “Totally Self-Checking (TSC)” (p. 8) and mechanism of their quantification.
iii. Quantity dependability attributes of relays supposed in the thesis (p. 9).
iv. Is your assertion “The basic method how (to) increase reliability is to increase the number of devices.” (p. 13) true unconditionally? Prove or disprove.
v. Why you decided not to utilize the Xilinx Macro (p. 29) and did not compare your approach to an approach based on the Xilinx Macro?
vi. What are the principles behind synchronizing a design after its reconfiguration (p. 35)?
vii. Why there are no edges from “Latent” to “Fault_Free”, “Fix_All” to “Hazard”, “Fix_FPGA” to “Hazard” in Fig. 4.5 (p. 36)? Justify; alike for Fig. 4.6 (p. 37).
viii. Have you considered a Single Point of Failure (SPF) during the dependability assessment of designs based on a single FPGA? Explain.
ix. Discuss (whether there is) a difference between the “repair” and “recovery” terms.

7. The overall evaluation of the dissertation: The evaluation is both heavily and negatively affected by many shortcomings/weaknesses in the thesis. The most significant ones follow: i) unclear aim and relevance, weak setting of the problem, failed to set research questions/hypotheses, ii) missing some key introductory parts and references, iii) few publications as a whole and no own publication in a scientific level journal, iv) writing is weak, numerous grammatical/spelling errors are apparent, v) results apply to a very limited set of platforms/designs, which raises many questions about scalability, general applicability, contribution etc. of the proposed approach. The strengths of the thesis are in minority and include: ii) understanding of the subject matter and associated literature, ii) a specific novelty and originality in the proposed approach, iii) appropriate evaluation/comparison of the proposed approach to alternative approaches and showing that the proposed approach may overcome the others under some circumstances, iv) justifying most of conclusions and supporting them through data. In summary, my current rating of the thesis is borderline. But, I would welcome to revise the thesis to make it more beneficial for its prospective readers and the reputation of its author and his institution.

8. Statement whether you DO or DO NOT recommend the dissertation for the defense: The author of the dissertation proved the ability to conduct research and achieve scientific results. In accordance with par. 47, letter (4) of the Law Nr. 111/1998 (The Higher Education Act) I do recommend the thesis for the presentation and defense with the aim of receiving the Ph.D. degree.

Yours sincerely,

in Brno,
on November 6, 2017

[Signature]

Reviewer
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I read carefully the thesis (twice) and the general impression is that it is an interesting work that resembles to a collage of experiences (very coherent with respect to the title of the thesis) more than a homogeneous activity under a single research project.

In some of these experiences the novelty of the contribution is clear (I think in particular to the UMDS method) in some others not (methods for reliability implemented on FPGA) in some others again the novelty is questionable (FTA for comparing reliable designs, duplication with SIL4) because it is not clear from the thesis the comparison with the state of the art.

The other weakness of the thesis is in the quality of the English grammar and style. A lot of typos and mistakes are spread throughout the paper and sometimes prevent the reviewer from understanding well what is the real contribution of the work. Indeed since this thesis will be a public document this is a not trivial aspect.

Finally the scientific production can be considered acceptable although not brilliant since the candidate presents 10 communications to international conferences (during the very long period 2010-2017) (2 of which seem to be posters) and 2 technical communications. No publications on journal or indexed journals have been produced.

Following the suggested scheme:

The topics dealt with in the thesis are surely of interest in the scientific community. The comparison of the work done with that performed by other authors or research groups is rarely present so it is not always possible to evaluate the quality of the work done and its novelty.

2. Formal structure and organization of the dissertation.
This is the most critical point since the structure of the thesis is easy to understand but the level of the English used in the manuscript is very poor and sometimes does not allow to understand what the author means or what he did.

3. Completion of the dissertation objectives.
The declared objectives of the work seem to be achieved. Their significance in the scientific context should be clarified

4. Assessment of the methods used in the dissertation.
The methods used in the work come from the analysis of the literature so it is possible to say that the level of assessment is acceptable

5. Evaluation of the results and contributions of the dissertation.
It is hard to evaluate the results since often there is no comparison with other works so the novelty is difficult to establish. Sometimes the work seems related to the implementation of methods taken from the literature (that in any case should be better discussed and not only described, showing pros and cons) and it is not clear if their performance could depend on the particular test case chosen or not.
A discussion of the significance of the case study chosen would be appreciated (is it very representative of all the possible applications or is it just a particular situation considered?)

6. Remarks, objections, notes, and questions for the defense.
In case of defense my main concern is to provide a better comparison between the work done (and its relative results) with the current state of the art.

7. The overall evaluation of the dissertation.
Interesting but not completely mature

8. Statement whether you DO or DO NOT recommend the dissertation for the defense.
Due to the concepts presented, some new ideas and their relative results this thesis deserves to be defended. My recommendation however is under condition provided that a clear explanation of the novelty of the work and an improved version in terms of readability is given during the defense.

Francesco Leporati
Ph. D. Thesis Review

Author: Ing. Pavel Vít

Thema: Dependable design methods for programmable circuits with respect to area overhead

Reviewer: Vlastimil Vavříčka

1. Characteristic and actual significance of the topic

The increasing complexity of todays embedded computers enforces new approaches to security issues. The subject of the thesis is of paramount importance for the design of highly reliable control systems. In the past few years, the topic has been intensively studied, because the possibility of reconfiguration of running devices which are implemented in modern FPGA comprises a wide range of opportunities to improve the reliability and fault-tolerance. Therefore the topic of the thesis is current and relevant in the context of up-to-date research.

2. Formal structure and organization of the dissertation

The text of the thesis spans almost 79 pages and has been divided into 7 chapters. At the end there are some formal parts as Bibliography and List of Publications. The formal features of the thesis correspond with standard requirements. On the other side, it seems that the student has been dealing with the subject for a long time which results in a certain loss of ability to describe the details. Despite its logical structure, the thesis is on many places difficult to read because of insufficient level of English of the author.

3. Completion of the dissertation objectives

The main goal of the thesis was to develop FPGA based control structure which is supposed to suppress the impact of SEU (Single Event Upset) on the structure’s function. Chapter 4 presents the core of the thesis. In this chapter the author deals with reliability models of designed control devices and evaluates their reliability and availability. He investigates several alternative architectures and compares their resulting reliability parameters. In this way, he documents the improvement of the reliability parameters of the proposed Upgraded Modified Duplex System. All outcomes and results contribute to fail-safe digital system design for railway applications and partially also to automotive applications.

4. Assessment of the methods used in the dissertation

The author has created several reliability models for proposed architectures that are listed in Chapter 4. Investigating the reliability parameters using simulation I consider the correct and usable solution. However the problem is that the thesis does not sufficiently describe how the results have been achieved. I refer in particular to paragraphs 4.6 and 4.7. of the thesis.

5. Evaluation of the results and contribution of the dissertation

The proposed architectures with increased reliability are using a certain type of redundancy. The author could show improvements of the failure distribution function of the Upgraded Modified Duplex System in comparison with the failure distribution function of the Modified Duplex System. From my point of view, I could not understand how the author obtained functions shown in Figure 4.9. It is not
clear whether this is the result of a simulation or if he obtained the course of the functions analytically.

6. Remarks, notes and questions for defense

There are a lot of comments and questions to the thesis, some of them only of a formal nature:

1. The student often operates with terms that are not exactly defined. As an example the definition of MTTR on the page 8 could be mentioned.
2. The list of abbreviations on the page xiii is not complete which makes the reading more difficult.
3. The formula (2.1) on the page 8 is not correct. In the case that the repair time is close to zero, availability reaches the value 0.5 which does not correspond to reality.
4. The equations (2.2) and (2.3) on the page 14 have undefined parameters A, B, C and D. What are they used for? The abbreviation ST denotes “Self-Testing”. The resulting value according to the equation (2.3) in % refers to the time or to the size of tested area or to something else?
5. Chapter 3 of the thesis deals with technological processes in the design of automata in FPGA environment. As a case study, counters are used to demonstrate the effect of SEU on the various implementations using FPGA with LUT3 and LUT4 on one side and with LUT6 on the other. The behavior of both versions is simulated and the results are compared. The results are interesting, but only loosely related to the rest of the work. Above that, this case study is closely linked to a specific structure of Xilinx LUT and does not reflect other possible organizations.
6. The figure 3.3 on the page 23 represents a structure of railway station control blocks. The explanation of components and their functions is poor or missing.
7. The sentence on the page 24 “Counters were converted from sequential logic into combinational logic” is at least very awkward and is in direct contradiction with the definition of sequential logic.
8. The equation (3.3) on the page 25 and its explanation is a little bit misleading. The probability of occurrence of an empty set phenomenon should be mathematically equal to zero. In this case, is it different? What was the equation (3.3) used for?
9. From the reader’s point of view the figure 4.2 does not tell much because the functions of individual blocks remain unknown.
10. Chapter 4, the central part of the thesis, evaluates probability models of the Modified duplex system and Upgraded modified duplex system. The results shown in the figure 4.9 are promising. The probability parameters listed on page 37 are used for the quantification. Their origin is not listed anywhere, although they can influence the results significantly. There is no description of how the curve in Figure 4.9 was derived.

The PhD thesis follows the diploma thesis of the author and is part of a larger project, dealt with at the department. I miss the strictest definition of the author’s share in the overall result.

7. Overall evaluation of the dissertation

The author of submitted work has focused on an important topic, the solution of which is demanding and potentially contributes to the higher reliability of digital systems not only in the automotive area. The style in which the presented thesis has been written, establishes a potential for later research and developing this particular area of reliable systems.
On the other hand I have the above mentioned serious objections to processing quality, which should be clarified at the defense.

There are about 12 reviewed publications at prestigious international conferences and workshops that relate to the thesis. The work contributes to the improvement of system properties designed on the basis of FPGAs. The results of the thesis can have a direct positive impact on practical applications.

Author’s research was also partially supported by Ministry of Education, Youth and Sport of the Czech Republic under research program MSM 6840770014 and by several student grants.

Ing. Pavel Vit has demonstrated his ability to focus on a topical important subject and to conduct scientific research. In accordance with par. 47, letter (4) of the Law Nr.111/1998 (The Higher Education Act) I recommend the thesis for the presentation and defense with the aim of receiving the Ph.D. degree.

Pilsen, January 12th, 2018

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