Identify minimal failure-causing schemas for multiple faults

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Combinatorial testing(CT) is proven to be effective to reveal the potential failures caused by the interaction of the inputs or options of the System Under Test(SUT). To extend and make full use of CT, the theory of Minimal Failure-Causing Schema(MFS) was proposed. The use of MFS helps to isolate the root cause of the failure, which is the next step of detecting them by CT. Many algorithms has been proposed to find the MFS in SUT, in our recently studies, however, we find these approaches cannot behave effectively when encounter multiple faults. The main reason why these methods failed to behave normally is that most of them ignore the masking effects hiding test cases, which can bias their identified results. In this paper, we extend the MFS theory to make it support the multiple faults testing scenarios, and hence can deal masking effects. Based on this, we gave an approach to identify the MFS which can alleviate the impacts of masking effects for multiple faults. In addition, we combine multiple algorithms to further improve the performance. Several empirical studies were conducted and showed that our approach can considerably improve the accuracy when identifying MFS in SUT with masking effects.

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Additional Key Words and Phrases: Software Testing, Combinatorial Testing, Failure-inducing combinations, Masking effects

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1. INTRODUCTION

With the increasing complexity and size of modern software, many factors, such as input parameters and configuration options, can influence the behaviour of the SUT. The unexpected faults caused by the interaction among these factors can make testing such software a big challenge if the interaction space is too large. One remedy for this problem is combinatorial testing, which systematically sample the interaction space and select a relatively small set of test cases that cover all the valid iterations with the number of factors involved in the interaction no more than a prior fixed integer, i.e., the *strength* of the interaction.

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Once failures are detected, it is desired to isolate the failure-inducing combinations in these failing test cases. This task is important in CT as it can facilitate the debugging efforts by reducing the code scope that needed to inspected.

In this article, we propose MMSN, abbreviation for Multifrequency Media access control for wireless Sensor Networks. The main contributions of this work can be summarized as follows.

— To the best of our knowledge, the MMSN protocol is the first multifrequency MAC protocol especially designed for WSNs, in which each device is equipped with a single radio transceiver and the MAC layer packet size is very small.
— Instead of using pairwise RTS/CTS frequency negotiation [Adya 2001,Culler 2001; Tzamaloukas 2001; Zhou 2006], we propose lightweight frequency assignments, which are good choices for many deployed comparatively static WSNs.
— We develop new toggle transmission and snooping techniques to enable a single radio transceiver in a sensor device to achieve scalable performance, avoiding the nonscalable "one control channel + multiple data channels" design [Natarajan 2001].

2. BACKGROUND

2.1. Definitions

2.2. Propositions

3. ALGORITHMS

3.1. Problem Formulation

4. PERFORMANCE EVALUATION

5. CONCLUSIONS

6. TYPICAL REFERENCES IN NEW ACM REFERENCE FORMAT

APPENDIX

ELECTRONIC APPENDIX

The electronic appendix for this article can be accessed in the ACM Digital Library.

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Online Appendix to: Identify minimal failure-causing schemas for multiple faults

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A. THIS IS AN EXAMPLE OF APPENDIX SECTION HEAD

B. APPENDIX SECTION HEAD

The primary consumer of energy in WSNs is idle listening. The key to reduce idle listening is executing low duty-cycle on nodes. Two primary approaches are considered in controlling duty-cycles in the MAC layer.

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