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CAGEN: A fast combinatorial test generation tool with support for constraints and higher-index arrays

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***Abstract*—In recent years, combinatorial testing methods have been successfully applied to test systems with a larger number of input parameters. Generating combinatorial test sets for such complex systems is a challenging task as it requires a lot of time and computing power. To tackle that issue, high performance tools are required. In this work, we present the combinatorial test set generation tool CAgen. It is capable of generating combinatorial test sets significantly faster than other state-of-the-art tools, such as ACTS, and contains various features such as constraint handling and higher-index arrays. It is highly compatible with other combinatorial testing tools and is available as CLI and Web-GUI. CAgen aims to make combinatorial testing more efficient and more accessible and user-friendly.**

I. INTRODUCTION

Due to the reduction in the number of tests necessary when using combinatorial testing methods, it has become possible to test larger systems within reasonable time and resources, while maintaining certain coverage guarantees. At the same time, the generation of combinatorial test sets with a small number of tests becomes increasingly difficult as the systems under test become larger [1], [2]. To counteract this, tools are necessary that are both fast and memory-efficient. Even for smaller systems, faster generation times can lead to reduced testing cycle durations. Furthermore, in order for combinatorial testing to be adopted by a wider set of software testers and developers, the tools necessary to edit, generate and inspect combinatorial test sets need to be user-friendly, enabling a quick development cycle. Both these properties aim at lowering the entry barrier to people unfamiliar with combinatorial testing. However, presently there is a distinct gap in the space of combinatorial testing tools making a widespread adoption harder than necessary. In the following, we will outline a few problems of the current state-of-the-art and then propose a new tool to bridge this gap.

One of the largest problems hindering adoption is the way in which different tools are distributed. Classic software distribution via pre-compiled binaries or bundles has the drawbacks of having no easy way to implement software updates by the vendor and placing a high maintenance burden on the provider depending on the number of supported platforms. Therefore, System as a Service (SaaS) solutions are becoming a more and more popular way to bring a software product to the end user with control remaining at the side of the vendor. In case of defects, bug fixes can quickly be deployed to the service and new versions are immediately available to all users. Recently, the authors in [3] surveyed existing combinatorial test generation tools which are available via the web. However, their analysis concludes that many of these tools have deficiencies which prevent their use in many testing scenarios. Most are commercial and thus not readily available to entry-level testers, students or academic users. Furthermore, some tools only offer limited support for higher strength test generation with three out of five tools only supporting pair-wise test generation and only one with support for 6-way coverage. As a response, in the same work, the authors proposed a new tool named CTWEDGE, which offers test set generation with either ACTS or CASA and is accessible via a web frontend. Furthermore, in [4] a tool for automated combinatorial test generation and fault characterization was intruduced, where the algorithm underlying CAgen was used for initial test set generation.

In this work, we present CAgen[1], a fast, efficient and user-friendly combinatorial test generation tool. To evaluate its features and performance, we will draw comparisons with the following tools: for GUI functionality, we consider ACTS [5], which comes as a command line tool as well as a GUI version, and the publicly available service CTWedge [3] that offers free test set generation using ACTS or CASA. Further, we will analyze the performance of our tool against the state of the art test set generation tools ACTS and PICT.

The paper is structured as follows. Section II gives an overview about algorithms used in test set generation and constraint handling. The architecture of CAgen is explained in detail in Section III and Section IV introduces the various features of CAgen and compares them with other generation tools. Section V provides benchmarks for various different instances of covering arrays, including models from real world applications, and compares them with ACTS and PICT, while Section VI concludes our work and discusses potential future work.

II. BACKGROUND AND RELATED WORK

The efficient generation of *covering arrays* (CAs), the mathematical construct underlying combinatorial test sets, is a highly researched topic [6]. Various generation methods,

[1]Publicly available at https://matris.sba-research.org/tools/cagen

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