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Nomadic People Optimizer for IoT Combinatorial Testing Problem

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***Abstract*— Nowadays, smart cities depends on the integration between the systems via internet connections which are known as the Internet of Everything (IoE). The integrated systems raise several concerns involving the potential presence of critical integration defects. Therefore, there is a need for an interaction testing approach. In this paper, we present a Nomadic People Optimizer as a search engine for the test list generation for interaction testing. The proposed test list generation strategy is called Nomadic People Strategy (NPS). The results show the NPS is also capable of outperforming the existing strategies such as Genetic Algorithm (GA), Ant Colony Algorithm (ACA), Coco Search Algorithm (CS), Harmony Search Algorithm (HS), Jaya Algorithm (JA), Firefly Algorithm (FA) and Melody Algorithm (MA).**

Keywords—software testing, internet of everything, integration testing, interaction testing, search-based testing, optimization algorithms.

I. INTRODUCTION

Currently, technology is everywhere in our daily life. The increasing of the technology based on the number of systems integrated through the internet is called the Internet of Everything (IoE). IoE, has many devices such as sensors, actuators, which are expected to be integrated into applications [1]. To ensure, the reliability of the IoE systems there are several testing approaches such as Performance testing and functionality testing are widely used. The heterogeneity and collaborative nature of IoE systems require extensive and scalable testing to ensure functional correctness. Therefore, combinatorial testing is required to test the interaction (interfaces) between the integrated systems[2].

Many combinatorial testing strategies have been introduced based on optimization algorithms such as Algorithm (GA) [3], [4], Ant Colony Algorithm[5], Coco Search Algorithm (CS)[6], Harmony Search Algorithm (HS)[7], Jaya Algorithm (JA), Firefly Algorithm (FA)[6], high-level hyper-heuristic (HHH) [8].

A new optimization algorithm based on Nomadic people lifestyle has been introduced by Salih and Alsewari [9]–[12] to solve engineering problems called Nomadic people optimizer (NPO). The performance of the NPO compared to well-known optimization algorithms solving engineering problems motivate us to adopt the NPO as the search engine to generate a test list for combinatorial testing problems.

The main contribution in this paper is the development of the new combinatorial test list generation strategy based on NPO.

The organization of the paper will be as follows: Section II shows the existing state-of-the-art strategies in the combinatorial testing. Section III elaborates the methodology. The results and the discussion will be presented in section IV. The last section presents the conclusion.

II. RELATED WORKS

Combinatorial testing is to test the interaction between the system's inputs or interaction between IoE system's devices in practice, it's impossible to test all the interactions due to the number of system inputs and devices. Assume there is a part of a system to be tested which has got 20 input fields and 5 possible settings for each input field, then there are 5^{20} possible inputs to be tested. Another example, as the IoE system has 20 devices each device has two options (Active, not Active), the exhaustive test list has 2^{20} test cases. In this case, exhaustive testing is impossible even if we wish to test all combinations. Therefore, the expert tester suggests generating the test list based on a certain combination degree less than the number of the system's inputs such as ($6 >= d >= 2$) (d represent the combination degree).

Combinatorial testing is an optimization problem [1],[6], [8], [13]–[23], [35]. Therefore, many optimization algorithms have been adopted as the main search engine for test list construction.

Many well known optimization algorithms that are implemented as combinatorial testing strategies are Simulated Annealing (SA) [24], [25], Genetic Algorithm (GA) [26], [27], Ant Colony Algorithm (ACA) [26], [28], Harmony Search (HS) [29]–[31], Cuckoo Search (CS) [32], Bat Algorithm (BA) [33], Firefly Algorithm (FA) [6], Artificial Bee Colony (ABC) [34].

However, the existing combinatorial testing strategies based on the optimization algorithms showed good performance, but none of them guarantees to produce the optimum test list in all experiments due to the weakness of each algorithm that may stack in local optimum or be lost in the global search. Few of these algorithms can control between the local search and global search, but they need to tune the algorithm parameters.

Based on that this paper introduces the NPO algorithm due to its advantages such as no parameters to be tuned, it has a unique structure as multi-population search space, local search and the global search will be applied without parameters to control it. The next section will present the implementation of the NPO as a combinatorial Test list generation strategy.