Chapter 2
Application and Evaluation of Bee-Based Algorithms in Scheduling:
A Case Study on Project Scheduling

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ABSTRACT

Scheduling is a vital element of manufacturing processes and requires optimal solutions under undetermined conditions. Highly dynamic and, complex scheduling problems can be classified as np-hard problems. Finding the optimal solution for multi-variable scheduling problems with polynomial computation times is extremely hard. Scheduling problems of this nature can be solved up to some degree using traditional methodologies. However, intelligent optimization tools, like BBAs, are inspired by the food foraging behavior of honey bees and capable of locating good solutions efficiently. The experiments on some benchmark problems show that BBA outperforms other methods which are used to solve scheduling problems in terms of the speed of optimization and accuracy of the results. This chapter first highlights the use of BBA and its variants for scheduling and provides a classification of scheduling problems with BBA applications. Following this, a step by step example is provided for multi-mode project scheduling problem in order to show how a BBA algorithm can be implemented.

INTRODUCTION

Scheduling, a complex optimization problem is an area of research that needs improvement using new methods and approaches. Solving this problem, which has a huge number of constraints; within acceptable levels of time and precision is a challenge. Scheduling problems can be solved up to some degree using traditional engineering models, algorithms, heuristics and meta-heuristics. Hence, methods employed

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by living creatures in order to solve their problems for survival in nature; are inspiring researchers in many different ways which help to develop models for solving daily life problems. Optimization is one of the prominent fields where natural systems are providing foresight to generate acceptable solutions (Pham et al., 2005; Karaboga and Akay 2010).

Various natural systems (social insect colonies) such as bees or bacteria (Escherichia coli bacteria) indicate that very simple individual organisms can create systems which are able to perform highly complex tasks by dynamically interacting with each other and adopting social foraging behavior (Teodorovic et al., 2006; Tang, Nouri, and Motlagh, 2011). In recent years, a noticeable pattern has been observed in the area of academic scheduling where many complex problems were efficiently solved using the principles of meta-heuristics (Teoh, Wibowo, and Ngadiman, 2015). For instance, as an evolutionary computational approach, Passino (2002) is inspired by the foraging behavior of Escherichia coli bacteria in human intestines. Here, the bacterium striving to maximize the energy gained per unit of foraging time is seen as an optimization process (Passino, 2002). Tang, Nouri, and Motlagh, (2011) adapted this approach to the machine cell formation problem.

A recent algorithm based on the interesting breeding behavior such as brood parasitism of certain species of cuckoos combined with the Lévy flight behavior of some birds and fruit flies, is an example of this kind (Yang and Deb, 2009). Cuckoo Search Algorithm is thought to be a new and efficient population-based heuristic evolutionary algorithm for solving optimization problems with the advantages of simple implementation and few control parameters (Nguyen, Vo, and Truong, 2014). It is applied to the problems of hybrid flow shop scheduling (Marichevlam, Prabaharan, and Yang, 2014; Dasgupta and Das, 2015), short-term hydrothermal scheduling (Nguyen, Vo, and Truong, 2014; Nguyen and Vo, 2015; Nguyen and Vo, 2016), multi-objective scheduling (Chandrasekaran and Simon, 2012; Akbari and Rashidi, 2016) and 2-machine robotic cell scheduling (Majumder and Laha, 2016).

Fireflies are creatures which have also affected researchers with their bioluminescence abilities. The flashing light of fireflies attract mating partners (communication) and potential prey, and this light is formulated in such a way that it is associated with the objective function to be optimized (Yang, 2009). The researchers idealized some of the flashing characteristics of fireflies to develop a firefly inspired algorithm to solve optimization problems (Gandomi, Yang and Alavi, 2011; Ritthipakdee et al., 2014).

In another study, by using the navigation method of moths in nature which is called transverse orientation, the moth-flame optimization method is developed (Mirjalili, 2015). This method is also called moth swarm optimization and mimics to the orientation of moths towards moonlight to solve the constrained Optimal Power Flow problem (Mohamed et al., 2017).

Besides, the Bat Algorithm introduced to literature by Yang (2011) is inspired by the echolocation property of bats. This property is a type of sonar that guides bats in their flying and hunting behavior and provides them to move and distinguish different types of insects even in complete darkness (Yang, 2010). Topal and Altun introduced the dynamic virtual bat algorithm using only two bats to find the optimal solution (2016). Chakri et al., (2017) developed the directional bat algorithm to overcome premature convergence that can occur due to the low exploration ability of the standard bat algorithm. Some problems solved using bat algorithms are optimization problems (Yılmaz and Küçüksille, 2015), neural networks (Jaddi, Abdullah, and Hamdan, 2015), process planning (Wang et al., 2015), planning the sports training sessions (Fister et al., 2015), and visual tracking (Gao et al., 2016a).

Furthermore, the most recent bio-inspired algorithms are flower pollination algorithm (Yang, Karamanoğlu, and He, 2014) developed for applications in the domain of global optimization problems with multiple diverse criteria and multiple objectives and artificial plant algorithm (Cui and Cai, 2013)