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THE EFFICIENT SELECTION METHODS OF GENETIC ALGORITHM USED IN SCHEDULING PROBLEMS

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ABSTRACT

The performance of a genetic algorithm (GA) depend on many factors: the selection method is one of them. It is well known that the genetic algorithm efficiency depends to a high degree upon the selection of the good GA operators and parameters that suitable to the different scheduling problems. In this paper, we find the selection methods of genetic algorithm that are more suitable for scheduling problem. Also, a number of selection methods used in scheduling problem have been described in this paper like random selection, roulette wheel selection, rank selection and tournament selection. The make span is the measure of performance used to evaluate the genetic selection methods. This paper will help researchers in selecting appropriate selection methods for different scheduling problems for better results.

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INTRODUCTION

Scheduling problem is an assignment problem, which can be defined as the assigning of available resources (machines) to the activities (operations) in such a manner that maximizes the profitability, flexibility, productivity, and performance of a production system (Prakash *et al*., 2011). GA was developed by Holland in 1975. It is a search technique based on the mechanics of natural genetics and survival of the fittest. The GA object determines which individuals should survive, which should reproduce, and which should die. Since GAs are adaptive and flexible, they were shown to be successfully applied to several optimization problems (Al-Rawashdeh and Al-Rawashdeh, 2015). GA is a method for moving from one population of "chromosomes" to a new population by using a kind of "natural selection. The selection operator chooses those chromosomes in the population that will be allowed to reproduce, and on average, the fitter chromosomes produce more offspring than the less fit ones (Saneh and Asha, 2017). Selection is the process of choosing two parents from the population for crossing.

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The purpose of selection is to emphasize fitter individuals in the population so that the offsprings hence produced have higher fitness (Nisha Saini, 2017). The selection of individuals for the production of the next generation is a critical process in GA. The individuals that are chosen for reproduction and the number of children each selected individual produces are determined by the selection mechanism. The underlying principle of selection strategy is "the fitter an individual is the higher is its chance of being parent" (Oladele and Sadiku, 2013). The selection phase determines which individuals are chosen for mating (reproduction) and how many offspring each selected individual produces. The main principle of selection strategy is "the better is an individual; the higher is its chance of being parent." The process that determines which solutions are to be preserved and allowed to reproduce and which ones deserve to die out. The primary objective of the selection operator is to emphasize the good solutions and eliminate the bad solutions in a population while keeping the population size constant (Saneh and Asha, 2017).

Literature Review: Tang and Liu 2002 proposed a GA for scheduling problems with the objective to minimizing mean flow time. They used roulette wheel selection (*RWS*).

Eliter *et al*. 2004 proposed a GA -based heuristic for the scheduling problems with makespan criterion. They used *RWS*. Iyer and Saxena 2004 proposed a GA for the scheduling problems with the objective of minimizing the makespan. They used *RWS*. Ruiz *et al*. 2006 proposed a hybrid genetic algorithm (HGA) that uses a simple form of local search based on the NEH heuristic. The objective is to minimize the makespan. For the selection of parents, they have chosen two selection schemes, rank selection (*RKS*) and tournament selection (*TTS*). Sadegheih 2006 proposed a GA using ranking selection (*RKS*). The algorithm is tested on 8-jobs and 7-machines example.

Wang *et al*. 2006 proposed a hybrid genetic algorithm for permutation scheduling problems with limited buffers with the objective to minimize the makespan. In the HGA. They used *RWS*. Octavia *et al*. 2007 discussed the application of hybrid genetic algorithm to solve practical scheduling problems. They used *RWS*. Zbigniew and Łukasz 2007 proposed a hybrid genetic algorithms for the open-shop scheduling problem. They used *TTS*. Adusumilli *et al*. 2008 proposed a GA for two machines FSP to minimize some of finishing time of arbitrary number of jobs. They used *RWS*. Kahraman *et al*. 2008 proposed a GA for scheduling problems with the objective of minimizing makespan. Two selection methods: *RWS* and *TTS* with probabilities (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, and 1.0). Kim and Jeong 2009 proposed a flow shop scheduling with no-wait flexible lot streaming (FSS-nwFLS) using adaptive GA to minimize the makespan. They used *RWS*. *Florentina Alina 2010* described the using of genetic algorithms for production scheduling. The selection method used *RWS*.

Kahraman *et al*. 2010 proposed a GA based on a permutation representation of the n jobs of HFSP with multiprocessor task problems to minimize makespan. They RWS and TTS. Rajiv Kumar *et al*. 2010 describe a crossover probability distribution in GA under process scheduling problem. They used RWS and TTS. Anna Ławrynowicz 2011 proposed a GA for solving scheduling problems in manufacturing systems. They used RWS and TTS. Engin *et al*. 2011 proposed a GA based on a permutation representation of the n jobs of HFSP with multiprocessor task problems to minimize makespan. They used RWS. Verma and Dhingra 2011 described multiprocessor task scheduling in the form of scheduling problems, which has an objective function for minimizing the makespan.

They proposed RWS. Chen *et al*. 2012 proposed a self-guided GA for permutation to minimize makespan. In the proposed algorithm. They used TTS. Imran and Abdul Munem 2012 presented a minimizing makespan for a no-wait flowshop using genetic algorithm. They used RKS. Kebabla, and Mouss 2012 proposed a local search genetic algorithm for the job shop scheduling problem. They used TTS. Neelam and Varshney 2012 proposed a model to study genetic algorithm for the flow shop scheduling problem. They used RWS. Tyagi and Varshney 2012 introduced the concept of a GA and described a GA-based heuristic for solving FSP with makespan criterion. They used RWS. Imran *et al*. 2013 proposed a genetic algorithm for flexible job shop scheduling. In the proposed algorithm. They used RMS. Jorge Magalhaes 2013 presented a comparative study of crossover operators for genetic algorithms to solve the job shop scheduling problem. They used RWS.

Feng *et al*. 2014 introduced the using of the heuristic genetic algorithm in multi-runway aircraft landing scheduling. In the proposed algorithm. They used RWS. Harwin *et al*. 2014 presented an optimizing production scheduling using genetic algorithm in textile factory. They used RWS. Shahsavari *et al*. 2014 proposed a novel genetic algorithm for a flow shop scheduling problem with fuzzy processing time. They used RWS. Vedavyasrao *et al*. 2014 proposed a comparative study of different representations in genetic algorithms for job shop scheduling problem. In the proposed algorithm. They used RWS. Milošević *et al*. 2015 presented an overview of genetic algorithms for job shop scheduling problems. In the overview algorithm. They used RWS and TTS. Saleha *et al*. 2015 proposed a solving job shop scheduling problem with genetic algorithm. They used RMS. Bhosale and Kalshetty 2016 proposed a genetic algorithm for job shop scheduling. They used RMS. Dr.V.Selvi 2016 proposed a parallel line and machine job scheduling using genetic algorithm. They used RWS and TTS. Ellur and Ramasamy 2016 proposed a study of crossover operators for genetic algorithm and proposal of a new crossover operator to solve open shop scheduling problem. They used RMS. Nguyena and Baob 2016 proposed an efficient solution to the mixed shop scheduling problem using a modified genetic Algorithm. They used TTS. Muhammad Ridwan 2016 proposed a knowledge-based genetic algorithm for solving flexible job shop scheduling problems. The selection method used RMS. Abd Elrahman *et al*. 2017 presented an optimizing dynamic flexible job shop scheduling problem based on genetic algorithm. They used RKS. Gordan *et al*. 2017 presented an applying improved genetic algorithm for solving job shop scheduling problems. They used TTS. Seyed Hosseini 2017 proposed a multi-objective genetic algorithm (MOGA) for hybrid flow shop scheduling problem with assembly operation. In the proposed algorithm, they used RWS. Md. Humayan *et al*. 2018 presented an application of an efficient genetic algorithm for solving $n \times m$ flow shop scheduling problem comparing it with branch and bound algorithm and tabu search algorithm. They used RMS. Raushan and Sridhar 2018 presented a minimization of makespan in job shop scheduling with heuristic and genetic algorithms. They used RKS. Based on Table (1) we detect *four* selection methods used in designing different genetic algorithms for solving scheduling problems as shown in Table (2)

Efficient Selection Methods of Genetic Algorithm used in Scheduling Problems: The approach of selection mechanism is to select individuals from the current population to create better individuals or better solutions. Fitter the individual, better is the chance of its selection as selection procedure is based upon the strategy of survival of the fittest. There are various ways to perform selection of the individuals to create offspring. (Smit *et al*., 2015). Some common ways of performing selection methods for most scheduling problems are: random selection, roulette wheel selection, tournament selection and rank selection.

Random Selection (RMS): The random selection (RS) is a very simple technique to select parents from the population at random. In terms of disruption of genetic codes, the random selection is a little more disruptive on the average than RWS. In this technique, all of the individuals are allocated equal reproduction opportunities (Abid Hussain *et al*., 2017).

Table 1. Summary of selection methods of genetic algorithms used for solving scheduling problems.

Author/s	*Year*	*Criterion*	Selection Method
Tang and Liu	2002	mean flow time	RWS
Eliter *et al.*	2004	makespan	RWS
Iyer and Saxena	2004	makespan	RWS
Ruiz *et al.*	2006	makespan	RKS, TTS
Sadegheih	2006	makespan	RKS
Wang *et al.*	2006	makespan	RWS
Octavia *et al.*	2007	makespan	RWS
Zbigniew and Łukasz	2008	makespan	TTS
Adusumilli *et al.*	2008	makespan	RWS,TTS
Kahraman *et al.*	2009	makespan	RWS
Florentina Alina	2010	makespan	RWS
Kahraman *et al.*	2010	makespan	RWS, TTS
Rajiv Kumar *et al.*	2010	makespan	RWS, TTS
Anna Ławrynowicz	2011	makespan	RWS, TTS
Kahraman *et al.*	2011	makespan	RWS, TTS
Kim and Jeong	2011	makespan	RWS, TTS
Engin *et al.*	2011	makespan	RWS
Verma and Dhingra	2012	makespan	TTS
Chen *et al.*	2012	makespan	RWS
Imran and Abdul Munem	2012	makespan	RKS
Kebabla, and Mouss	2012	makespan	TTS
Neelam and Varshney	2012	makespan	RWS
Tyagi and Varshney	2012	makespan	RWS
Imran *et al.*	2013	makespan	RMS
Jorge Magalhaes	2013	makespan	RWS
Feng *et al.*	2014	delay time	RWS
Harwin *et al.*	2014	makespan	RWS
Shahsavari *et al.*	2014	makespan	RWS
Vedavyasrao *et al.*	2014	makespan	RWS
Milošević *et al.*	2015	makespan	RWS, TTS
Saleha *et al.*	2015	makespan	RWS
Bhosale and Kalshetty	2016	makespan	RMS
Dr.V.Selvi	2016	makespan	RWS, TTS
Ellur and Ramasamy	2016	makespan	RMS
Muhammad Ridwan	2016	makespan	RMS
Nguyena and Baob	2016	makespan	TTS
Abd Elrahman *et al.*	2017	makespan	RKS
Gordan *et al.*	2017	makespan	TTS
Seyed Hosseini	2017	makespan	RMS
Md. Humayan *et al.*	2018	makespan	RWS
Raushan and Sridhar	2018	makespan	RKS

Table 2. Selection methods used in scheduling problems

#	Selection Methods	Codes
1	Random Selection	RMS
2	Roulette Wheel Selection	RWS
3	Tournament Selection	TTS
4	Rank Selection	RKS

Roulette Wheel Selection (RWS): Roulette wheel selection is a method for selection, in which the average fitness of each chromosome is calculated depending on the total fitness of the whole population. The chromosomes are randomly selected proportional to their average fitness. Roulette wheel selection is summarized in the following steps: (Engin *et al*., 2011)

Step 1. Let the pop-size equal the number of strings in population.

Step 2. n sum is the sum of all of the fitness values of the strings in population; form n sum slots and assign a string to the slots according to the fitness value of the string.

Step 3. Do step 4 (pop-size -1) times.

Step 4. Generate a random number between 1 and n sum, and use it to index into the slots to find the corresponding string; add this string to new pop.

Tournament Selection (TTS): Tournament selection is probably the most popular selection method in genetic algorithm due to its efficiency and simple implementation. In tournament selection, *n* individuals are selected randomly from the larger population, and the selected individuals compete against each other. The individual with the highest fitness wins and will be included as one of the next generation population. The number of individuals competing in each tournament is referred to as tournament size, commonly set to 2 (also called binary tournament). Tournament selection also gives a chance to all individuals to be selected and thus it preserves diversity, although keeping diversity may degrade the convergence speed. The tournament selection has several advantages which include efficient time complexity, especially if implemented in parallel, low susceptibility to takeover by dominant individuals, and no requirement for fitness scaling or sorting. (Oladele and Sadiku, 2013)

Rank Selection (RKS): This method overcomes the scaling problem of roulette wheel selection method where the fitness differs very much. The fittest individual occupies the largest section on the wheel, thus further minimizing the probability of least fit individual. The rank selection method ranks the individual in increasing order of fitness from 1 to N.

Therefore, even the worst individual in the population has rank 1. The probability that an individual is selected is directly proportional to its ranking, rather than its fitness values. Thus, if an individual is 10 times or 5 times better than the next individual, its selection probability will not differ that much. Each individual is weighted by its rank rather than its absolute fitness. (Smit *et al*., 2015)

Conclusion

In this paper, we find the efficient selection methods of genetic algorithm that are more suitable for scheduling problem and described these types of selection methods in the GA procedure. Where the makespan is the measure of performance used to evaluate the genetic algorithm selection methods. We find that the tournament selection (TTS) and the roulette wheel selection (RWS) are most used in the scheduling problems.

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