Volume: 1 Issue: 1 [September, 2016] pp.10 - 17]
Journal of Information System and Technology Management
eISSN: 0128-1666
Journal homepage: www.jistm.com

RESCHEDULING FOR JSSP AND FJSSP USING CLONAL SELECTION PRINCIPLE APPROACH – A THEORY

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Accepted date: 7 August 2016, Published date: 11 September 2016

Abstract: *This article was discussed about rescheduling technique for the job-shop scheduling problem and flexible job-shop scheduling problem by using clonal selection principle approach. Job-shop and flexible job-shop scheduling problems are one of the most frequently encountered and hardest to optimize. This article begins with a short brief about scheduling and production scheduling in the dynamic environment. There are two main causes that required for rescheduling process included machine breakdown factor and new job arrival factor. This article will be discussed for this two factor and suggest the several technique for rescheduling process.*

Keywords: scheduling, artificial intelligence, job-shop scheduling, robustness, artificial immune system, evolutionary computation, rescheduling, dynamic scheduling

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Introduction

Scheduling allocates shared resources over time to complete activities with hard or soft constraints given. In essence, scheduling can be considered a searching or optimization problem, with the goal of finding the best schedule. Production scheduling are among the most common and significant problems faced by the manufacturing industry. Production scheduling problems deal with scheduling jobs on a machine (or a set of machines) in order to optimize a specific objective function such as total weighted completion time or total weighted tardiness.

Recently, in the dynamic environment of the manufacturing industry, to refer to job-shop or flexible job-shop problems obtained by the best schedules with the optimal solution is not sufficient. There has a gap between real world and computer theories. Inaccurate information is the main factor for this gap. Different constraints in the theory and real world also become a factor for this gap. In real world, changes suddenly often happen and indirectly it will be different with original theory.

For example, in theory by using any solving methods we can obtain the solution for the job-shop scheduling problem and flexible job-shop scheduling problem. But, the changes suddenly often happen while the implementation of this solution. In this chapter we will discusses the changes or factor disturb the solution of the JSSP and FJSSP. There are two major factor always disturb the implementation process of the solution included machine breakdown and new jobs arrival. For the rescheduling process, there are several strategy based on the causes of the rescheduling. Rescheduling always happen in the dynamic environment and it's also call dynamic scheduling. The first study in dynamic job shop scheduling was published by Holloway and Nelson (1974). They presented a hybrid method based on the genetic algorithm and dispatching rules for solving job shop scheduling problems with sequence-dependent setup times and due date constraints.

Rescheduling is triggered whenever a machine breakdown occurs (Yamamoto and Nof 1985). Nof and Grant (1991) developed a scheduling/rescheduling system and analyze the effects of process time variation, machine breakdown and unexpected new job arrival in a manufacturing cell. In their scheduling system, monitoring is performed periodically and either rerouting to alternative machines or order splitting policies are activated in response to unexpected disruptions. Adibi et al. (2010) has using variable neighborhood search (VNS) to solve the dynamic scheduling problem cause by machine break down and random job arrivals. He *et al.* (2008) was introduced multi agent technique to solving the job shop scheduling problem in dynamic environment to meet the customer requirement such as new product demand.

Rescheduling for Machine Breakdown Factor

The rescheduling is affected only for an uncompleted operation and it's prevent the use of a preplanned schedule (Bean *et al.* 1991). Chryssolouris and Subramaniam (2001) was proposed algorithm for dynamic job shop with unreliable machines, multiple job routes and multiple scheduling criteria using genetic algorithms.

As Bean *et al.* (1991) said, for machine-breakdown problems the rescheduling is affected only for an uncompleted operation. For example, let say there are thirty operations for JSSP and eighteen from this operation already completed and twelve operations is uncompleted. So, only twelve uncompleted operation will be rescheduling based on constraint given. Figure 1 illustrate the JSSP and Figure 2 illustrates the antibody represent for JSSP shown in Figure 1. While Figure 3 illustrates the solution / schedule and Figure 4 illustrates the machine breakdown problem.

	Machine			Time		
	O_1	O_2	O_3	O_1	O_2	O_3
Job$_1$	1	2	3	4	3	2
Job$_2$	2	1	3	1	4	4
Job$_3$	3	2	1	3	2	3
Job$_4$	2	3	1	3	3	1

Figure 1: Job Shop Scheduling Problem

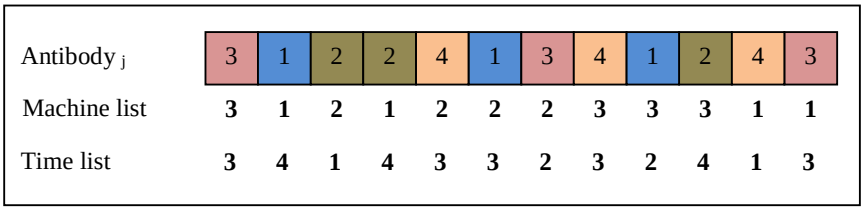

Figure 2: Antibody for JSSP

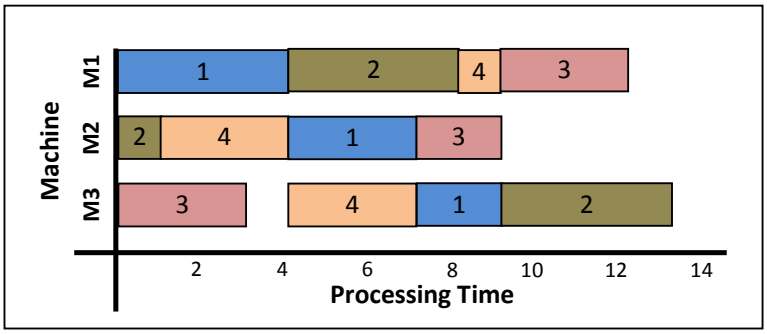

Figure 3: Schedule (Gantt Chart) for JSSP

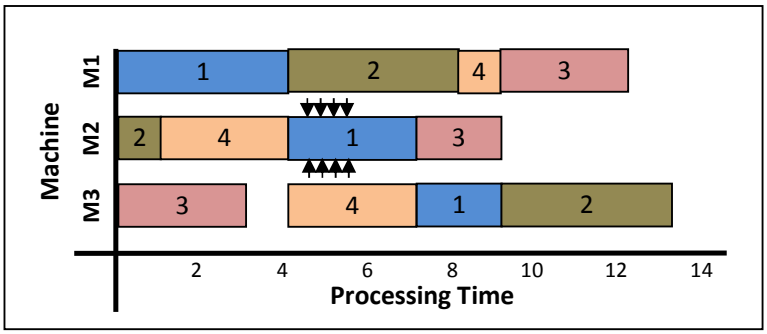

Figure 4: Machine Breakdown

Referring to Figure 4, we can see that machine two has experienced a breakdown after completed the two operations, and it still has two operations waiting to be completed. Then, if we look at machine one at this time, it has three operations to be completed, but it two can only complete. This is causes by last operation on machine one have a preceding operation on machine two can't be complete. While on the machine three, third operation can't be complete because it's has a preceding operation on machine two.

In the new solution from rescheduling process, only the operational sequence on machine three has been changed. Using the clonal selection principle approach, the rescheduling process for problems cause by machine breakdowns, can be determined by means of random integer string that contains the job on a machine that has not broken down and is operation on job with no preceding operation to be completed. Figure 5 illustrates the antibody for machine breakdown and the antibody after the repaired process. While Figure 6 shown the new schedule after machine breakdown.

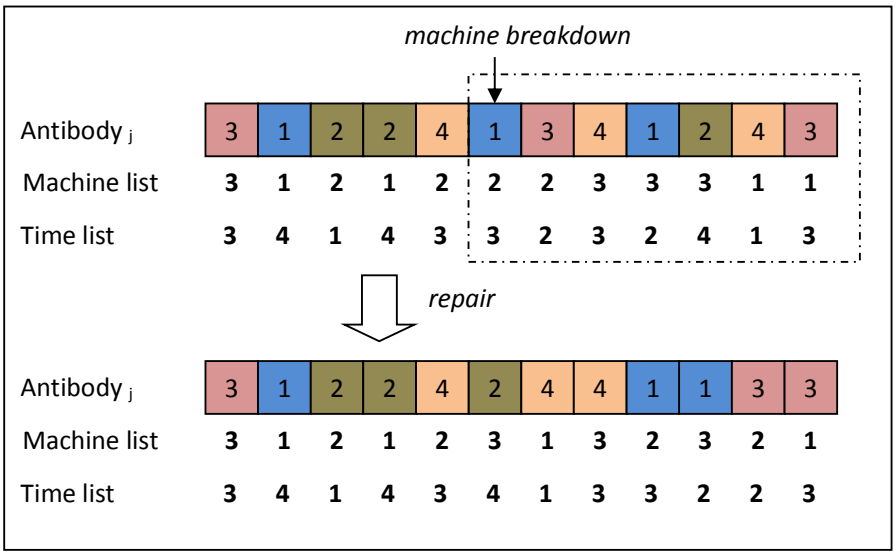

Figure 5: Antibody for Machine Breakdown

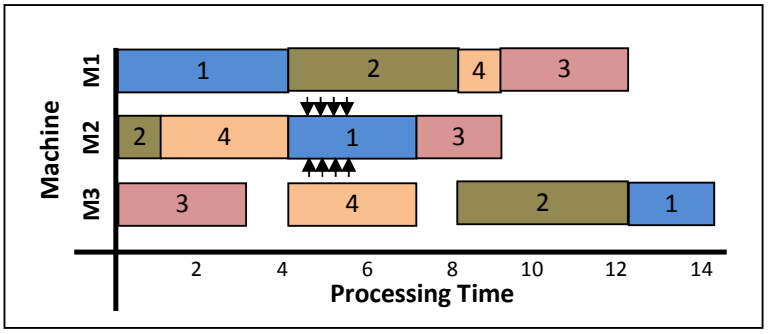

Figure 6: New Schedule (Gantt Chart) after Machine Breakdown

New Job Arrival

There are many techniques and methods can be used for rescheduling process cause by new job arrival. This article will discuss are several strategies. For rescheduling caused by a new job arriving during the machines completing a current job, two types of rescheduling can be implemented. There are four strategies can be used as follows:

i. Scheduling the new jobs after completion the current jobs.
ii. Scheduling the new jobs immediately and continue with current jobs after completion the current jobs.
iii. Scheduling the new jobs by insert into idle time during completion the current jobs.
iv. Scheduling the new jobs immediately and insert the current jobs into idle time during completion the current jobs.

Strategy one and strategy two will be implement when the current jobs important than current jobs or the due date for the new jobs early from the due date of the current jobs. Let say, the antibody and schedule for the current jobs as shown in Figure 2 and Figure 3, while the Figure 7 and Figure 8 illustrate the new jobs and antibody for new jobs. This new job arrived after

machine one and machine three completed one operation, and machine two completed two operations. Figure 9 illustrates the decoding process using strategy one and strategy three, while Figure 10 and Figure 11 illustrate the decoding process using strategy two and strategy and strategy four.

	Machine			Processing Time		
	O_1	O_2	O_3	O_1	O_2	O_3
Job_1	1	2	3	3	3	3
Job_2	1	3	2	2	3	4
Job_3	2	1	3	3	2	1

Figure 7: New Jobs Arrive

Antibody $_j$	1	2	3	3	1	2	1	2	3
Machine list	**1**	**1**	**2**	**1**	**2**	**3**	**3**	**2**	**3**
Time list	**3**	**2**	**3**	**2**	**3**	**3**	**3**	**4**	**1**

Figure 8: Antibody for new Jobs

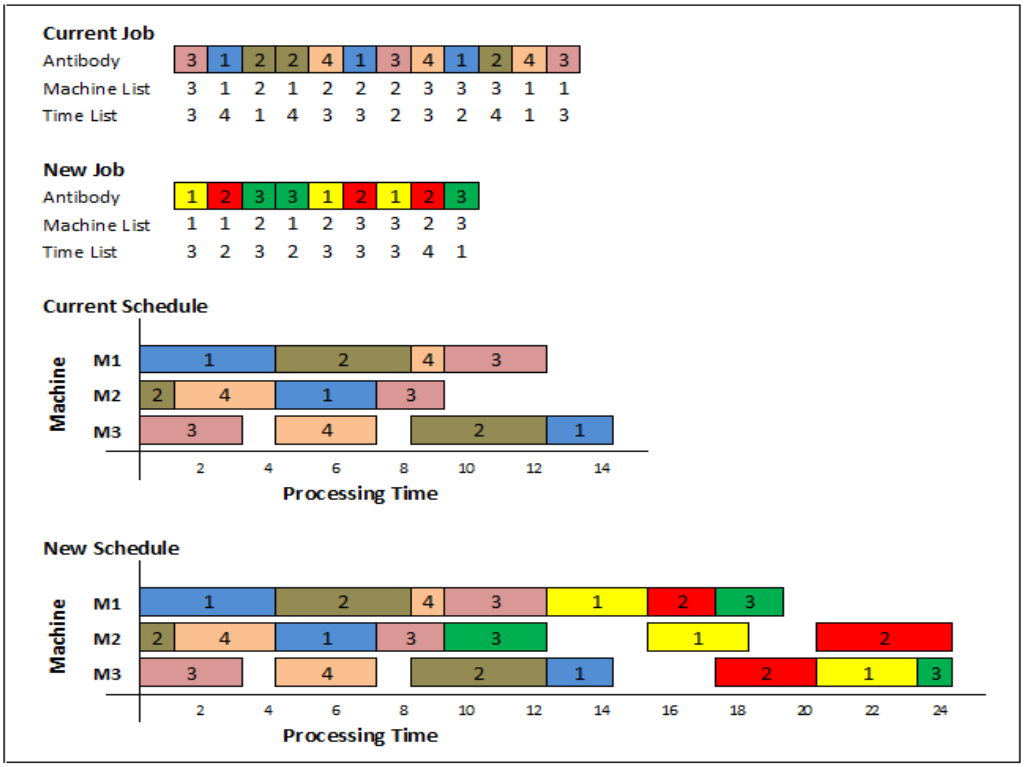

Figure 9: Rescheduling for New Job Arrival using Strategy One and Three

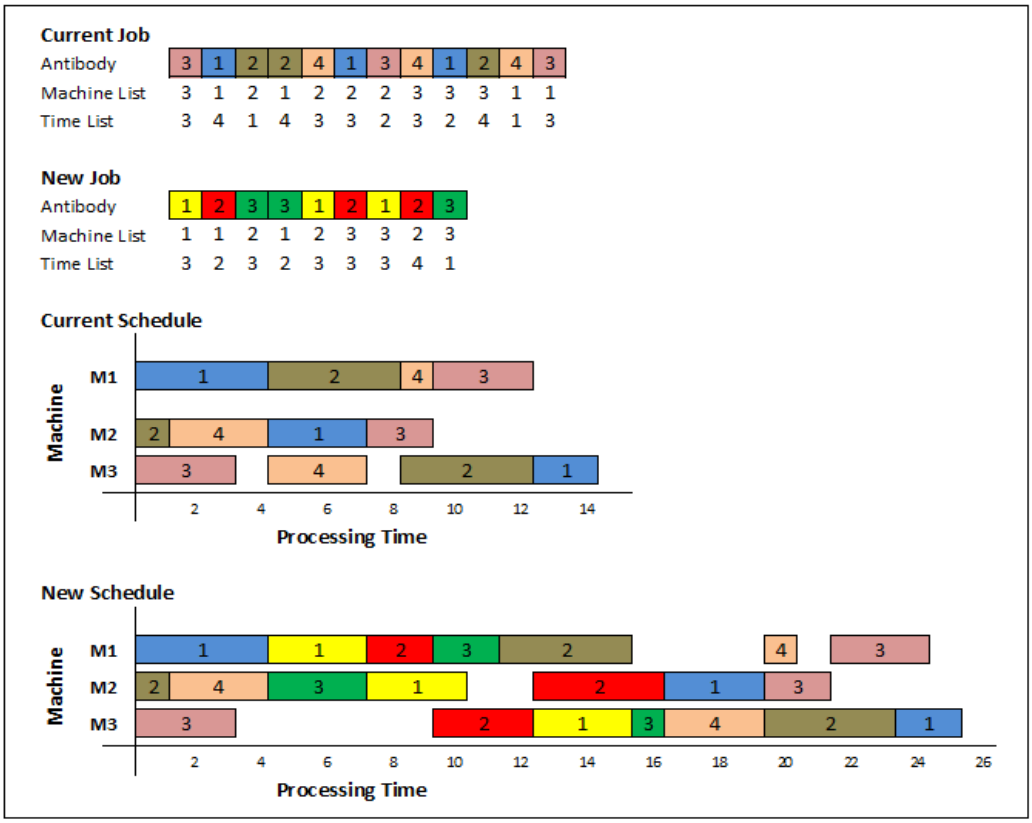

Figure 10: Rescheduling for New Job Arrival using Strategy Two

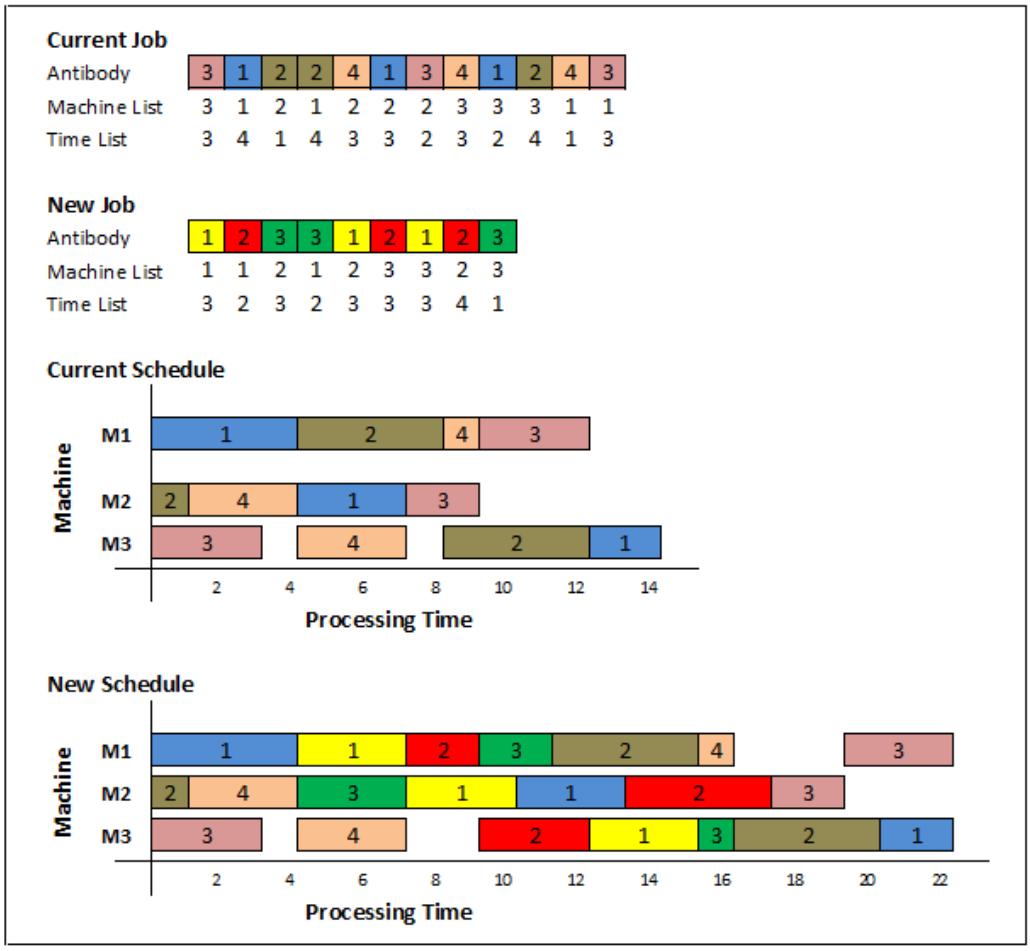

Figure 11: Rescheduling for New Job Arrival using Strategy Four

Conclusion

This article introduced basic concept of rescheduling theory using clonal selection principle. Based on techniques and strategies was explained with the example, clonal selection principle can be use to overcome the dynamic environment for the production scheduling. However, there are need a future study and investigating to ensure all techniques are flexible and can be implement to all types of dynamic environment in the production scheduling. Following item, described suggestion for the future works:

1. Explore an algorithm to overcome all types of dynamic environment for job-shop scheduling problem.
2. Produce hybrid model to solving the dynamic environment problem.

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