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Hybrid strategy based complete rescheduling approaches for dynamic *m* identical parallel machines scheduling problem with a common server

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ABSTRACT

In this paper, a simulated annealing and seven dispatching rule based complete rescheduling approaches are proposed for the dynamic *m* identical parallel machines scheduling problem with a common server to generate new schedules depending on the hybrid rescheduling policy. A priority based performance measure is proposed to minimize the number of tardy jobs as primary goal and the square root of the mean-squared deviation for due dates as secondary goal. The proposed complete rescheduling approaches are executed in a hypothetical simulation case to minimize the proposed performance measures under different scheduling frequencies and due date tightness factors. The rankings of the proposed approaches are compared by using simple additive weighting method under different weighting scenarios. The utility results indicate that simulated annealing based complete rescheduling method produces better scheduling performance when compared to dispatching rule based complete rescheduling methods in general.

1. Introduction

Manufacturing systems are complex, dynamic, and stochastic systems with a wide variety of products, processes, production levels, and unexpected disturbances [1]. Mostly, it may be possible to formulate these problems, but solving these to optimality may require an enormous amount of computer time [2]. Therefore, instead of the optimal solution, maintaining a feasible solution alone can sometimes be the only goal of the scheduling practice [3]. When a dynamic and stochastic manufacturing environment is encountered in which static scheduling may be impractical, the use of real time scheduling approaches is required [1]. The reader can refer to Ouelhadj and Petrovic [4] for the detailed survey on dynamic scheduling in manufacturing systems.

Simulation is a powerful tool to analyse complex, dynamic and stochastic systems and a simulation-based real time scheduling system is usually composed of four main components [5]: “a monitoring system to collect data from the physical shop floor; a simulator to generate simulation models, run the models, and analyse their results; a decision-making system to generate decisions such as schedules and priority rules; and an execution system to control the shop floor”.

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In simulation based approaches, the scheduling mechanism can be activated by significant operational changes (i.e., event triggered) or at the end of each time interval, which is constant or non-constant. In the event triggered (or event driven) approaches, an initial schedule is generated at the beginning of a period and it is revised when such significant operational changes occur as major breakdowns, minor breakdown, and new part arrivals [6]. The reader can refer to Negahban and Smith [7] for the recently published survey on simulation approaches for manufacturing systems.

In modern manufacturing systems, some resources such as a piece of equipment or a team of setup workers or a single operator may be required throughout the setup process. Each of these situations defines a scheduling problem with a common server. The type of server may vary according to the production environment. This problem occurs frequently in production environments such as manufacture of automobile components and printing industry [8]. Some examples from the literature which indicate the importance of the problem and related application areas in the industry can be found at Huang et al. [8], Kravchenko and Werner [9], Hall et al. [10], Glass et al. [11], Guirchoun et al. [12], and Kim and Lee [13].

Numerous real time scheduling approaches have been developed for various manufacturing systems, including single machine systems, parallel machines systems, flow shops, job shops, and flexible manufacturing systems. However, the real time scheduling of m parallel machines scheduling problem with a common server and sequence dependent setup times is not studied in the relevant literature.

Since the two identical parallel machines scheduling problem with a common server and sequence dependent setup times is *NP*-hard [9,14–16], then m identical parallel machines scheduling problem with a common server and sequence dependent setup times is also *NP*-hard.

In this paper, a simulated annealing (*SA*) and seven dispatching rule (*DR*) based complete rescheduling approaches (*CRA*s) are proposed for the dynamic m identical parallel machines scheduling problem with a common server to generate new schedules depending on the hybrid rescheduling policy. A priority based performance measure is proposed for aiming at minimizing the number of tardy jobs (*NTJ*) as primary goal and the square root of the mean-squared deviation for due dates (*SRMSD*) as secondary goal. A tardy job is defined as a job whose completion time is later than its due date. In other words, a tardy job is a late job. This criterion is important since, in many cases, the cost penalty incurred by a tardy job does not depend on how late it is, but the fact that it is late. In such cases, an appropriate objective would be to minimize the number of tardy jobs. On the other hand, the purpose of Just-in-Time (*JIT*) manufacturing is to reduce inventory costs and satisfy customer demands with on time deliveries. In *JIT*, the products that are finished early cause higher inventory costs and those that are finished after their due dates may cause a customer to switch to another supplier [17,18]. In this study, the minimization of *SRMSD* is tackled as secondary goal, which is a poorly addressed *JIT* objective in related literature. The proposed complete rescheduling approaches are implemented in a hypothetical simulation case to minimize the proposed priority based performance measure under different scheduling frequencies and due date tightness factors. The rankings of *CRA*s are compared by using simple additive weighting (*SAW*) method [19] under different weighting scenarios.

The rest of this paper is organized as follows. A literature survey on the parallel machines scheduling problem with server is given in Section 2. In Section 3, problem definition and the proposed hybrid rescheduling approach are presented in detail. Development of the simulation model is described in Section 4. Proposed simulated annealing based complete rescheduling approach (*SA*/*CRA*) and dispatching rule based complete rescheduling approaches (*DR*/*CRA*s) are presented in Section 5. Subsequently, computational experimental results are reported in Section 6. Finally, conclusions are given in Section 7.

2. Literature survey

The published papers are summarized by taking into account the solution approaches, setup types, and the production environments and the summary is presented in Table 1.

According to this summarized review, only two papers (Zhang and Andrew [25], Su [31]) dealt with the dynamic parallel machines scheduling problem with a common server and they focus on two identical parallel machines. However, two identical parallel machines are not able to respond the higher product volume.

This summarized review also reveals there is no paper handled the dynamic m identical parallel machines scheduling with a common server and sequence dependent setup times. This paper bridges this gap for this problem.

3. Problem definition and proposed hybrid rescheduling approach

In this section, a detailed explanation of the problem and proposed solution methodology are given.

3.1. Problem description

Production orders, that may be generated from a requirement planning system or directly originated from customers' orders, arrive one-by-one depending on stochastic inter arrival times on the m identical parallel machines system. Type of an arriving job is also stochastic. Stochastic breakdowns may occur on the machines and the job preemption is allowed. Each job requires a single operation and may be processed on any of the m parallel machines. The setup times for the machines are significant and sequence dependent, i.e., the setup time for one job is affected by its preceding job on the same machine. There is only one server serving to all machines for the setup process. Due to the complex nature of this system, the proposed *CRA*s are executed in a hypothetical simulation case to minimize the proposed performance measures