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Minimizing sum of the due date assignment costs, maximum tardiness and distribution costs in a supply chain scheduling problem

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ABSTRACT

In production systems, manufacturers face important decisions that affect system profit. In this paper, three of these decisions are modelled simultaneously: due date assignment, production scheduling, and outbound distribution scheduling. These three decisions are made in the sales, production planning and transportation departments. Recently, many researchers have devoted attention to the problem of integrating due date assignment, production scheduling and outbound distribution scheduling. In the present paper, the problems of minimizing costs associated with maximum tardiness, due date assignment and delivery for a single machine are considered. Mixed Integer Non-Linear Programming (MINLP) and a Mixed Integer Programming (MIP) are used for the solution. This problem is NP-hard, so two meta-heuristic algorithms, an Adaptive Genetic Algorithm (AGA) and a Parallel Simulated Annealing algorithm (PSA), are used for solution of large-scale instances. The present paper is the first time that crossover and mutation operators in AGA and neighbourhood generation in PSA have been used in the structure of optimal solutions. We used the Taguchi method to set the parameters, design of experiments (DOE) to generate experiments, and analysis of variance, the Friedman, Aligned Friedman, and Quade tests to analyse the results. Also, the robustness of the algorithms was addressed. The computational results showed that AGA performed better than PSA.

1. Introduction

Integrated Due date assignment, Production and outbound Distribution Scheduling (IDPDS) refers to problems that integrate three types of decisions: sales planning decisions (due date assignment), production scheduling, and distribution scheduling (see Fig. 1). These decisions are explained as follows:

Due date assignment: one of the decisions in sales planning is related to assigning the due dates of orders. Long due dates may cause loss of orders or requests for discounts from customers. Short due dates may cause costs related to tardiness, so determining appropriate due dates is very important.

Production scheduling: some decisions are considered in production systems, such as sequencing of jobs, assigning jobs to machines, and machine scheduling, but most of these systems do not consider delivery issues and outbound distribution.

Delivery scheduling: it is essential to consider the high costs of logistics for issues related to transportation system scheduling and delivery scheduling. These issues can affect the profitability of producers.

In the classic model of scheduling, the due date is considered a fixed parameter and an input of problem. Determining the due date and production scheduling at the same time can improve the efficiency of the production system and increase profitability. Gordon et al. [10] did the most recent review in this area [10]. Production and distribution are two important subjects in supply chain; so coordination of production and delivery planning is one of the most important issues. Chen [4] and Wang et al. [39] have done good reviews in this area [4,39].

Jackson [15] showed that sequencing based on the Earliest Due Date (EDD) on a single machine can minimize maximum tardiness [15]. There have been many studies on minimizing maximum tardiness on a single machine with different objective functions [35,36]. Luo and Chu [24] developed a branch and bound algorithm for the problem of minimizing maximum tardiness on a single machine with setup time [24]. Cheng et al. [6] addressed the problem of minimizing maximum tardiness for a single machine with setup time

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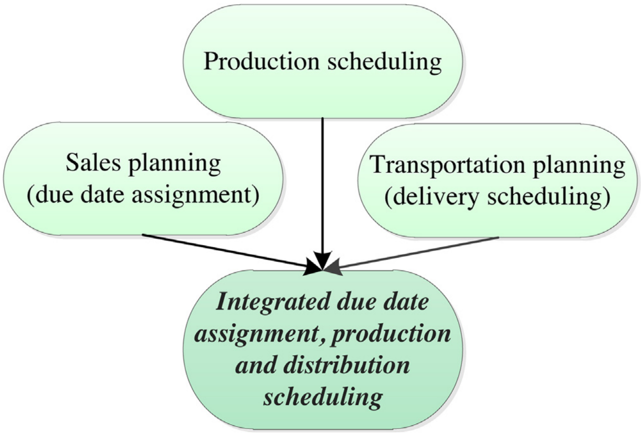

Fig. 1. IDPDS problems.

and deteriorating jobs, and provided a branch and bound algorithm to solve it [6].

Rasti-Barzoki et al. [30] studied minimizing the sum of the total weighted number of tardy jobs and delivery costs and introduced a new branch and bound algorithm, a heuristic algorithm for upper bound calculation and two approaches for the lower bound calculation [30]. Mahdavi Mazdeh et al. [25] provided a branch and bound algorithm for the problem of minimizing the sum of maximum tardiness and delivery cost on a single machine [25]. Wang and Lei [40] studied an integrated scheduling problem of supply and distribution operations in a make-to-order supply chain. They introduced the problem of minimizing the total costs of shipping and penalties incurred for unfulfilled customer orders, subject to network capacity and deadline constraints, and provided a heuristic algorithm for solving it [40]. Abedi and Seidgar [1] considered the problem of minimizing lateness, holding, delivery and due date assignment costs for a single-machine scheduling problem with batch delivery and release times in which due dates are controllable as realistic assumptions in the manufacturing environment. They introduced two meta-heuristic algorithms, a Bi-level Double Genetic Algorithm (BDGA) and a Bi-level hybrid Simulated annealing and Genetic Algorithm (BSGA) to solve the problem [1].

Li et al. [21] studied the problem of single machine due date assignment scheduling with uncertain processing times, and general precedence constraints among the jobs was also considered. The processing times of the jobs were assumed to be fuzzy numbers [21]. Rostamzadeh et al. [32] compared the existing models of supply, production and distribution in supply chain and introduced a model that integrates the mentioned criteria in supply chain management and provided a new method for the calculation of the fitness function in the process of a genetic algorithm [32]. Han et al. [13] introduced minimization of both makespan and delivery costs in on-line supply chain scheduling for single-machine and parallel-machine configurations in a transportation system with a single customer [13]. Karimi and Davoudpour [17] addressed the scheduling for a supply chain with interrelated factories containing suppliers and manufacturers. They developed a branch and bound algorithm to solve the problem. They presented a Mixed Integer Linear Programming (MILP) formulation and a pseudo-polynomial dynamic programming algorithm to solve the problem [17].

Rasti-Barzoki and Hejazi [29] studied an integrated due date assignment, production, and batch delivery scheduling problem with controllable processing times for multiple customers in a supply chain. The objective was to minimize the sum of the weighted number of tardy jobs, due date assignment, resource allocation, and batch delivery costs [29]. Lee et al. [19] studied the problem of minimizing the total tardiness of jobs from a first agent, given that the maximum tardiness of jobs from a second agent does not exceed an upper bound on a single machine in which jobs have different release times, and developed three genetic algorithms [19]. Yin et al. [44] introduced integrated production and batch delivery scheduling in a make-to-order production system involving two competing agents, each having its own job set competition to process its jobs on a shared single machine [44]. Janiak et al. [16] provided a survey of scheduling problems with due windows. They presented an extensive review of the literature concerning problems with various models of given due windows, due window assignment, and job-independent and job-dependent earliness/tardiness penalties [16].

Rostami et al. [31] considered minimizing the sum of maximum tardiness and delivery costs on a single machine with release times and presented a branch and bound algorithm and two meta-heuristic methods to solve it. Hamidinia et al. considered the problem of minimizing total tardiness/earliness of weighted jobs in a batched delivery system and used a genetic algorithm to solve it [12]. Hajiaghaei-Keshteli and Aminnayeri [11] considered the integrated scheduling of production and rail transportation and introduced two meta-heuristic algorithms, a genetic algorithm and a Keshtel algorithm [11].

Xu et al. [42] developed an improved hybrid version of the Chemical Reaction Optimization (CRO) method called HCRO (Hybrid CRO) to solve a Directed Acyclic Graph (DAG) based on a task-scheduling problem. Both simulation and real-life experiments have been conducted to verify the effectiveness of HCRO [42]. Xu et al. [43] proposed a task-scheduling scheme on heterogeneous computing systems using a Multiple Priority Queue Genetic Algorithm (MPQGA). The MPQGA method also designed a crossover, mutation, and fitness function suitable for the scenario of Directed Acyclic Graph scheduling [43].

Truong et al. [37] introduced a new chemical reaction optimization with greedy strategy algorithm (CROG) to solve the 0–1 knapsack problem (KP01). They also proposed operator design and parameter turning methods for CROG. They used a new repair function integrating a greedy strategy and random selection to repair infeasible solutions.Zhang et al. [45] investigated a novel reliability maximization with energy constraint (RMEC) algorithm, which incorporates three important phases: task priority establishment, frequency selection, and processor assignment [45]. Xu et al. [41] used the CRO scheme to formulate the scheduling of directed acyclic graph jobs in heterogeneous computing systems, and developed a double molecular structure-based chemical reaction optimization (DMSCRO) method. Simulation experiments were conducted to verify the effectiveness and efficiency of DMSCRO over a large set of randomly generated graphs, and graphs for real-world problems [41].

Garcia et al. [8] introduced a genetic algorithm for the problem of integrated production scheduling and delivery with time windows. Cheng et al. [5] introduced the problem of scheduling parallel batching machines in which jobs have arbitrary sizes. The jobs are processed in batches, and the total size of the jobs in a batch cannot exceed the capacity of the machine [5]. Cakici et al. [2] studied the problem of minimizing the total weighted tardiness and total distribution costs in an integrated production and distribution system, and introduced a genetic algorithm [2]. Li et al. [22] provided a SA for the problem of integrated production and delivery with one manufacturer and one distributer.

The main contributions of this paper are as follows:

1. The problem of minimizing sum of the due date assignment costs, maximum tardiness and distribution costs in a supply chain scheduling is studied for the first time in this paper.