

A Bee Algorithm for Parallel Batch Production Scheduling

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ABSTRACT

This paper presents a model for a supply chain consisting of a supplier, a manufacturer and a customer with objective of minimizing the delivery time of last order to customer (Makespan). The problem is first described and solved in small scales by Lingo 11.0. Then, because of problem complexity, a Bee Algorithm (BA) metaheuristic approach is developed to find near optimal solutions in reasonable run times.

Keywords: *Production scheduling; Supply chain; Makespan; Delivery; Bee Algorithm*

1. INTRODUCTION

In this paper a parallel machine scheduling problem on a three staged supply chain is considered consisting of a supplier, a production stage and a customer. For making orders, it is required to send a specific raw material from supplier to the manufacturing stage. Manufacturing stage is consisting of some identical parallel machines.

Also, there are two capacitated vehicles, one for transporting the raw materials to manufacturing stage and another for sending the completed orders to final customer.

Based on the arrival time of raw materials to manufacturing stage, a release date is considered for each order. The objective function of problem is to find a) a delivery schedule for raw materials from supplier to manufacturer, b) a production schedule in manufacturing stage and c) a delivery schedule for finished products from manufacturing stage to customer so as to minimize the delivery time of final order to customer (Makespan).

This problem is applicable in most real industries; especially those have a multi level production process in which an order has to be processed on various stages.

A schematic view of the problem is depicted as follows:

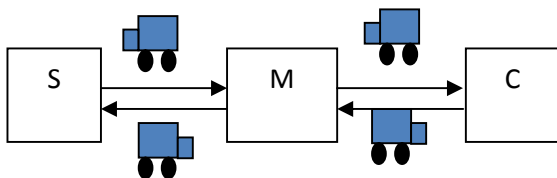


Fig 1: Schema of the supply chain

The reminder part of this paper is as follows:

Section 2 provides the related researches in terms of scheduling models in supply chain. In Section 3, the problem is algebraically formulated by introducing notations for the parameters and decision variables.

Section 4 describes the proposed algorithms by more details and computational experiments are conducted in

Section 5. Finally, the conclusion and some suggestions for future researches are mentioned in Section 6.

2. RELATED STUDIES

Supply chain management is one of the most important subjects which have attracted much attention in recent years and many researchers have emphasized it.

Also, many case studies are in the literature, focusing on the importance and motivation of scheduling issues in supply chain problems, especially in deliveries and productions (Naso et al [1], Amaro and Pova [2], Wang and Cheng [3], Oztemel and Kurt Tekez [4], Jiao et al. [5])

Hall and Potts [6] presented a pioneer paper on integrating the scheduling decisions in a supply chain. They studied various scheduling problems in a supply chain with overall scheduling and batching costs.

Torabi et al. [7] studied the problem of lot and delivery scheduling in a two stage supply chain involving a single supplier and an assembly facility, where the supplier produces multi-item on a flexible flow line and sends them directly to the assembly facility. Their objective was to minimize the average of holding, setup and transportation costs. Then, they proposed an enumeration method and a hybrid genetic algorithm. Selvarajah and Steiner [8] considered a simple two stage supply chain and modeled the problem as a single machine scheduling from the supplier's view. They developed a polynomial time algorithm to minimize the sum of inventory holding and delivery costs.

Tamani et al. [9] studied a design and the practical implementation of a multiple objective real time scheduling problem for a complex production system in which a continuous supervisory fuzzy approach is used for controlling and coordinating the production system.

3. PROBLEM DESCRIPTION

A three staged supply chain is considered consisting of a supplier, a manufacturer and a final customer. A specific raw material is required for producing the final production which is sent from supplier to manufacturer by a capacitated vehicle. For doing this transportation, the number of l trips is required in which the number of trips is equal to the upper bound of number of jobs by the capacity of vehicle $\lceil N/V \rceil$

Based on the arrival time of raw materials to manufacturing stage, a release date is considered for each order.

Manufacturing stage consists of M identical machines in which orders are processed on them and the final products are sent to final customer by another capacitated vehicle. For this circumstance, the number of trips is also calculated based on the upper bound of number of jobs by the capacity of vehicle $\lceil N/V \rceil$, as well.

The goal is finding (1) a delivery schedule for raw materials from supplier to manufacturer, (2) a production schedule for producing orders on machines in manufacturing stage and (3) a delivery schedule for finished products from manufacturer to customer so as to minimize the delivered time of last order to customer.

4. SOLUTION APPROACH

Bees Algorithm is a powerful optimisation algorithm inspired by the natural behaviour of honey bees to find the optimal solution.

The pseudo code of BA is as follows:

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Initialise population with random solutions.
Evaluate fitness of the population.
While (stopping criterion not met)
    Select sites for neighbourhood search.
    Recruit bees for selected sites (more
    bees for best elite sites) and evaluate fitness.
    Select the fittest bee from each patch.
    Assign remaining bees to search
    randomly and evaluate their fitness functions.
End While.
  
```

Fig 2: The pseudo code of proposed BA

5. COMPUTATIONAL STUDY

All the algorithms were coded using Matlab 7 and were run on a personal computer with CORE I 7 processor and 4 GB of RAM. The required data was generated randomly based on Wang and Cheng (2009) as follows:

- Processing time of jobs from uniform distribution [1-100]
- The traveling time from supplier to manufacturer as 150 unit time
- The traveling time from supplier to manufacturer as 178 unit time

In order to check the accuracy of proposed model, first some small instances of the problem are solved optimally using Lingo 11 global solver and are compared to results of BA. For each instance, the algorithms were run 5 times and the average of obtained solutions was considered as the best OFV (Objective Function Value).

As it can be concluded from Table 8, Lingo is incapable for solving the problem for some instances because of immense complexity of the problem.

Table 1: The comparison of results of proposed algorithms and Lingo global solver

M	Lingo 11 Global solver		BA	
	OFV	Run time (sec)	OFV (average)	Run time (sec)
2	261	44	261	3.36
	281	438	281	3.73
	-	-	404.6	4.43
3	261	305	261	2.49
	281	1854	281	3.13
	-	-	419.6	3.43

Where M and N shows the numbers of machines and orders respectively and other columns demonstrates the performance of proposed methods in terms of OFV and run time in seconds.

6. CONCLUSION AND FUTURE RESEARCHES

This paper studied the problem of production scheduling in a supply chain consisting of a supplier, a manufacturing stage and a customer. The problem goal is to find a) a delivery schedule for raw materials from supplier to manufacturer, b) a production schedule in manufacturing stage and c) a delivery schedule for finished products from manufacturing stage to customer so as to minimize make span and a Bee algorithm is presented for this purpose. In order to check the verification and validity the proposed model, some small instances of problem were solved optimally using Lingo 11 global solver and were compared to the results of proposed BA.

For future research, the problem can be considered in flow shop and job shop environments that are nearer to some real industries.

In terms of solution methods, the problem can also be solved optimally using branch and bound and branch and cut algorithms.

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