An Ant Colony Optimization Model for Parallel Machine Scheduling with Human Resource Constraints

Zhu Qiong[1], Gu Yichao[2], Zhang Gong[1], Zhang Jie[1], and Chen Xuefang[3]

[1] School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai, China, 200240
zhuqiong@sjtu.edu.cn, zhanggong@sjtu.edu.cn, zhangjie@sjtu.edu.cn

[2] Class 6 Grade 3, Shanghai Nanyang Model High School
cherryrain26@hotmail.com

[3] Department of Mechanical Electronic Engineering, Suzhou Vocational University, Suzhou, Jiangsu, China, 215104
Chenxf@jssvc.edu.cn

Abstract. This model proposed an ant colony optimization model to tackle human resource constrained parallel machine scheduling problem with precedence constraints. In this model, four subsystems are designed to solve the problem, including input subsystem which conducts the problem and the ACO model related parameters and output subsystem which exports scheduling and analysis results, sequence searching subsystem which constructs feasible sequence for each ant, human resource scheduling and sequence evaluation subsystem which assigns human resource and determines the duration time of jobs under the allowable amount of operators. The model is demonstrated to be valid using an example case.

Keywords: Parallel Machine, Scheduling, Ant Colony Optimization, Precedence Constraints, Human Resource Constraints.

1 Introduction

This paper addresses the problem of scheduling a set of jobs on a finite set of identical parallel machines in the presence of operators, and certain tasks can not begin until others are completed or should begin with others at the same time. The number of operators and the processing time required to perform each task on a machine is given. We are interested in assigning the tasks to operators and machines and scheduling the tasks in such a way that the time needed to finish all of the work is minimized. In other words, we wish to minimize the maximal job completion time, also called the makespan. This problem can be classified as a general parallel machine scheduling problem with multiple resources and precedence constraints. Even without precedence constraints or human resource constraints, minimizing the makespan is NP-hard problem.

The most popular approaches to scheduling problems with the objective of minimizing makespan are analytical and heuristic method. Analytical methods use mathematical programming, such as linear programming or dynamic programming, to

G. Huang et al. (Eds.): DET2009 Proceedings, AISC 66, pp. 917–926.
springerlink.com

solve problems (Chen and Song, 2009) (Ziaee and Sadjadi, 2007) (Nait et al, 2007). Generally, mathematical models are difficult to create and require lots computation effort. Thus, they are only suitable for small sized problems (Chen and Weng, 2009). Some heuristic methods have been developed to solve makespan problems due to their simple and ease-to-use feature. Although these methods could produce good solutions, they don't guarantee optimality and are proven to be problem dependent. Genetic algorithm, taboo search algorithm are examples of heuristic approaches. Recently, the ant colony optimization (ACO) algorithm has been popular in solving minimizing makespan problems. Behnamian et al. proposed ACO based hybrid algorithm to optimize makespan in the parallel machine scheduling problem with sequence dependent setup times (Behnamian et al, 2009). T'Kindt et al. proposed an ACO algorithm for the two machine flow shop scheduling problem (T'Kindt et al, 2002). The abovementioned makespan models did not address the problems regarding task relevant constraints, e.g., precedence relationship, human resource requirement constraints, etc.

In this paper, the authors integrated the ideas from the aforementioned research to form an ant colony optimization algorithm to tackle human resource constrained parallel machine scheduling problem. In this model, an ACO based time-resource analysis is used to determine the near optimal schedule under the allowable amount of operators for all the jobs.

The reminder of this paper is organized as follows. This paper is organized as follows: section 2 presents the problem formulation. Section 3 gives a general introduction about ACO algorithm. In section 4, the ACO model is developed for the proposed problem. In section 5, the experiment for performance measures and case study is made. Section 6 is conclusions.

2 Problem Formulation

In this paper, the following notations are used:

j	index of jobs
t	index of time units
H	total number of operators
N	the amount of jobs to be processed
M	total number of machines
π	the schedule sequence
C_j	the completion time of job j
p_j	the processing time of job j
O_j	the number of required operators for job j
$prelist_j$	the set of precedence jobs before job j
x_{jt}	the binary number, 1 if job j is processed in the t time period, 0 otherwise

The scheduling problem involves parallel machines with precedence and human resource constraints, i.e., we are given: (1) a set of N jobs with precedence constraints that induce a set of precedence jobs $prelist_j$ on the jobs; (2) a set of M machines, each