

Chapter VI

An Immune Algorithm Based Robust Scheduling Methods

Xingquan Zuo

Beijing University of Posts and Telecommunications, P.R. China

Hongwei Mo

Harbin Engineering University, P.R. China

ABSTRACT

Inspired from the robust control principle, a robust scheduling method is proposed to solve uncertain scheduling problems. The uncertain scheduling problem is modeled by a set of workflow simulation models, and then a scheduling scheme (solution) is evaluated by the results of workflow simulations that are executed by using the workflow models in the set. A variable neighborhood immune algorithm (VNIA) is used to obtain an optimal robust scheduling scheme that has good performances for each model in the model set. The detailed steps of optimizing robust scheduling scheme by the VNIA are given. The antibody coding and decoding schemes are also designed to deal with resource conflicts during workflow simulation processes. Experimental results show that the proposed method can generate robust scheduling schemes that are insensitive for uncertain disturbances of scheduling environments.

INTRODUCTION

In this paper, we proposed a robust scheduling method for uncertain scheduling problems. The method is based on workflow simulation models and an immune algorithm. We introduced the method of modeling uncertain scheduling problems by a set of workflow simulation models, and gave the detailed steps of optimizing the problems by the immune algorithm. In simulation experiments, we compared the proposed method with the definitive scheduling method, and experimental results shown that the robust scheduling method can improve the robustness of scheduling schemes and generate robust scheduling schemes that are insensitive to uncertain disturbances of scheduling environments.

BACKGROUND

Scheduling problems exist widely in actual production processes, and are very important for improving enterprise efficiency, reducing the labor of workers, and enhancing the competitive power of enterprises. In recent years, many scheduling methods are proposed, and most of them are used to solve definitive scheduling problems (Brucker, 1998; Hajri, 2000; Yang, 2001). But in actual production scheduling, there are a lot of uncertainties such as the uncertainty of process time and the failure of machines, which would lead the primary scheduling scheme become worst or even infeasible. Dynamic scheduling methods (Suresh, 1993) can solve such uncertain scheduling problems effectively, i.e., when dynamic events occur, a new scheduling scheme can be generated by rescheduling to deal with the changed scheduling environment.

Dynamic scheduling methods can generate feasible scheduling schemes, but for some trades such as civil aviation, frequent rescheduling is not a good idea and may cause some problems for airliners and passengers. When an accidental event occurs, we hope that the event would not influence the whole scheduled flight. In this condition, a “robust” flight scheduling is welcome that would still maintain good performances when the scheduling environment changes.

Along with the increasing requirement of robust scheduling method, researches on robust scheduling arouse much attention in recent years (Lin, 2004). Compared with dynamic scheduling, robust scheduling is a new research area, and there are still many problems needed to be solved, and the definition of robust scheduling has not been given explicitly until now. General speaking, robust scheduling can be considered as a suboptimum scheduling scheme that is not sensitive to noise environments, and it emphasizes on the stability of scheduling schemes. Byeon et al decomposed a scheduling problem into several sub-problems, and a heuristic algorithm was used to solve each sub-scheduling problem to obtain a robust scheduling scheme (Byeon, 1998). Jensen proposed a robust scheduling method based on robust optimization (Jensen, 2003). His method used a disconnected chart model to construct a scheduling neighborhood, all of the scheduling solutions in the neighborhood are used to evaluate scheduling schemes, and an optimal robust scheduling scheme is obtained by a genetic algorithm. Leon et al proposed a robust scheduling method based on genetic algorithm, and scheduling schemes was evaluated by the weighted sum of the expectation values and variances of the performance index “Makespan” (Leon, 1994).

Inspired from the ideas of robust control, a robust scheduling method is proposed in this paper. The method uses a set of workflow simulation models to describe an uncertain scheduling problem, and a robust scheduling scheme is obtained by a variable neighborhood immune algorithm. Scheduling solutions are evaluated by many workflow simulations that are executed by using the workflow models in the set. Different from other robust scheduling methods, the proposed method focuses on finding a global robust solution whose scheduling results are stable for uncertain scheduling environments, not just a local robust solution that is only robust for small uncertain disturbances. The proposed method is also different from those robust scheduling methods based on robust optimization: it tries to find a scheduling scheme (solution) that has stable scheduling results when the scheduling environment changes; while the robust optimization based methods try to obtain a scheduling scheme (solution) whose variety would not cause a large variety of scheduling results for a given scheduling environment.

MODEL OF UNCERTAIN SCHEDULING PROBLEMS

Workflow simulation scheduling model is a universal scheduling model that has good model description capability for large scale complex scheduling problems and their uncertain disturbances (Fan, 2001; Zuo, 2006). Hence, this paper uses the workflow simulation scheduling model to model uncertain scheduling problems. The scheduling model is composed of process model, resource model, and transaction model etc, and is capable of describing all kinds of scheduling problems.

- (1) **Process model:** The process model consists of multi-processes that are independent one another. Each of these processes describes the manufacturing procedures of a classification of jobs. The process model can describe the manufacturing procedures of all classifications of jobs, including job shop, flow shop, and hybrid scheduling problems etc. Each process of the model has several activities, and each activity denotes

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