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Multi-objective optimization model for multi-project scheduling on critical chain

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ABSTRACT

In this paper, a multi-project scheduling in critical chain problem is addressed. This problem considers the influence of uncertainty factors and different objectives to achieve completion rate on time of the whole projects. This paper introduces a multi-objective optimization model for multi-project scheduling on critical chain, which takes into consideration multi-objective, such as overall duration, financing costs and whole robustness. The proposed model can be used to generate alternative schedules based on the relative magnitude and importance of different objectives. To respond to this need, a cloud genetic algorithm is proposed. This algorithm using randomness and stability of Normal Cloud Model, cloud genetic algorithm was designed to generate priority of multi-project scheduling activities and obtain plan of multi-project scheduling on critical chain. The performance comparison shows that the cloud genetic algorithm significantly outperforms the previous multi-objective algorithm.

1. Introduction

A multi-project scheduling problem involves defining feasible start times and feasible resource assignments for activities so that the different optimization objectives, defined as part of the problem, are reached. Moreover, to solve the various uncertainty factors, it is necessary to have knowledge about the effectiveness of the uncertainty factors in relation to different project activities. Compared with multi-project scheduling, multi-project scheduling on critical chain for decisions had superiority in more complex since multi-objective and related to different aspects of the project (i.e., overall duration, idleness of resources, financing costs) must be considered in order to arrive at a efficient schedule. Decisions therefore cannot be based solely on optimizing a single criterion such as cost or duration, but require a multi-objective approach. To address this need, new methodologies and approach should be developed to meet decision support system. In this paper we explore the multi-objective of decision making in multi-project scheduling on critical chain (MPSCC) and propose a multi-objective optimization model formulation.

Critical Chain Method (CCM) is first proposed by Goldratte [13], which can optimize overall objective of projects better, raise rate of completion on time and shorted overall span by considering the uncertainty of task duration in projects. Considering the problem form the view of system, which eliminates the influence of "students syndrome" and "Parkinson Law", effectively solve the problem existed in multi-task between project interrelation and internal project. In multi-project management environment, multi-project scheduling on critical chain (MPSCC) have five steps: generating the priority of subprojects; planning and scheduling each subprojects according to Critical Chain Method; avoiding resource conflict among subprojects; setting various project buffers in multi-project environment, analyzing the buffer manage way to meet the objective of completion rate on time of the whole projects.

The fluctuation of duration and cost that involve subproject of multi-project, which bring serious challenge to the scramble for limited resources between subprojects [1,2]. In the literature, various kinds of multi-project scheduling problems have been described and addressed until now, nevertheless, few multi-project scheduling problems have efficient method for considering the uncertainty factors, which a important aspect in multi-project scheduling contexts. These problems state multi-objective optimization about the effectiveness of multi-project scheduling.

With advantages have received gradually, Critical Chain Method has being widely used in project management. In order to realize global optimization of multi-project scheduling on critical chain (MPSCC), the multi-objective optimization of time–cost–quality–robustness, which fits actual demand of engineering project better and provides theory basis for integrated management of project schedule in enterprises, was proposed in this article. The research target about multi-project scheduling in critical chain is mainly

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focused on time, cost and quality in China and abroad. However, the robustness will be an extremely valuable subject because of uncertainty and complexity in multi-project scheduling, which has become a hot topic with deeper research.

The existing techniques for multi-objective optimization can be classified into three categories: global search algorithms, mathematical programming models and heuristic algorithms. Previous research efforts have developed several scheduling techniques for multi-project scheduling. Several approaches to solve the multi-project scheduling problems, a one-stage and two-stage linear programming approach is proposed by Slowinski [20]. In order to solving lager-sized projects, heuristic and meta-heuristic procedures are proposed. Knotts et al. [21] design agent-based algorithm and Lova et al. [22] propose a multi-pass heuristics to solving the problems based on priority rules. However, previous researches do not consider the problem in dynamic scheduling, to find the optimal solutions, the multi model is proposed. To the best of our knowledge, no further research has been performed on the multi-project scheduling on critical chain. In this paper, we introduce a cloud genetic algorithm approach for solving the addressed problem.

The rest of the paper is organized as follows. In Section 2, presents a literature review with regard to classification of multi-project scheduling and associated scheduling models and methodologies. In Section 3, we introduce a multi-objective optimization formulation for modeling the scheduling of multi-project scheduling on critical chain (MPSCC), which allows multi-objective optimization with respect to duration or cost related criteria in the parametric design. In Section 4, designs cloud genetic algorithm, to solve the problem is described. In Section 5, the computational experiments developed to evaluate the performance of the cloud genetic algorithm are presented, and these results are analyzed. Finally, in Section 6, the conclusions of this paper are presented.

2. Related works

In the literature, various multi-project scheduling problems were proposed, but only few multi-project scheduling on critical chain (MPSCC) problems have researched. Yannibelli and Amandi [3]consider the effectiveness of a human resource and to minimizing the project makespan, and proposed a multi-objective evolutionary algorithm. Zheng et al. [4] address multiple projects in a deterministic environment, which analyzes resource-constraint multi-project scheduling with priorities and formulates, that a discrete bi-objective model is proposed. Vincent and Mario [23] considers asymmetric information and opportunistic behavior in resource constrained multi-project scheduling problems. Browning and Yassine [8] attempt to address the static resource-constrained multi-project scheduling problems, which consider how to allocate resource to minimize the average delay and maximize the time to complete the whole projects. Krueger et al. [9] consider sequence and resource dependent transfer times into multi-project scheduling problems, and formulated an integer linear program. Voss et al. [6] consider a multi-mode multi-project scheduling problems, which takes into consideration the weighted tardiness. A heuristic and a genetic algorithm for multi-project scheduling is proposed by Kumanan et al. [7], which reach an objective to minimize the makespan of the projects. Rabbani et al. [14] put forward a schedule method for resource-constrained random network project;

Bai et al. [12] design fuzzy Critical Chain Method based on genetic algorithm to solve the resource constrained project scheduling problems (RCPSP), Rabbani et al. [14] attempt to using Critical Chain Method to analyze resource-constrained project scheduling in stochastic networks, which suggests a competition routine by implementing a policy to maximize the total contribution of activities using a new heuristic algorithm. Bevilacqua et al. [15] illustrate that Critical Chain Method (CCM) can shorten the duration of the project and reduced operating costs in maximum through application instances. Peng and Xu [16] argue that the earlier the project begins, the lower risk of time delay is and presented improved ways of CCM. Salmasnia et al. [17] introduce quality parameters into the traditional time–cost tradeoff project scheduling problem. Based on analysis of research status on multi-project scheduling problem, multi-objective optimization scheduling problems and Critical Chain Method in project scheduling problems, scholars of domestic and overseas have been tried to innovate theoretical model and solving algorithm to find out more optimal multi-project scheduling scheme on critical chain.

Afshar et al. [10] introduce a finance-based scheduling concept to investigate multi-objective finance-based scheduling, which presents a multi-objective model that search the non-dominated solutions considering duration, required credit and cost as three objectives. Senouci and Al-Derham [11] present a genetic algorithm to solving multi-objective project scheduling problems. Yannibelli and Amandi [3] develop a multi-objective project scheduling model based on a hybridizing multi-objective simulated annealing algorithm with evolutionary algorithm.

In contrast with the above proposed problems, the influence of uncertainty factors in dynamic scheduling environment has not been considered in other multi-project scheduling problems, for this reason, we introduce multi-project scheduling on critical chain (MPSCC), which considers multi-objective in optimization model and presents cloud genetic algorithm to solve the problems.

3. Problem description

In this paper, multi-project scheduling on critical chain is addressed. The environment of MPSCC is more complicated and has higher demands about project cycle and resource utilization, in addition, Murphy's Law and Parkinson's Law is always involved. Thus, enough safety time should be reserved when making project activity durations to guarantee the project would be completed on time, however, ability against uncertainties will be weaken as this method distributes project risk into project activities. The existence of cascade effect is determined by the character of critical chain multi-project management, that is to say, the change of one project will lead to the change of another by shared resource, and because of this sharing, the service efficiency will be decreased when each project competes for resources. The ability of MPSCC against uncertainties can be lower, which means lower robustness, as delay of one single project will affect the others under multi-project circumstances. Abbasi et al. [18]designed a multiple objective model for project scheduling, which aims at the minimum of duration and maximization of robustness.

Based on the analysis above, the research goal of MPSCC can be divided into four categories: minimize total project duration, maximize robustness of project, and to use project resources in a balanced way. There are mainly three types of existing research: the first is single objective optimization, that is to choose one attribute from time, cost and quality as objective function to establish mathematical models; secondly, the three attributes are considered simultaneously in constructing multi-objective optimization models, which will be transformed into single-objective optimization and solved; thirdly, the robustness of solution in critical chain project scheduling and quality robustness are researched. In practical, time, cost and quality are three major concerns for operators, and the robustness of multi-project scheduling is the key to success of multi-project operation mode. However, there are no mature approaches for deep analysis of multi-objective problem in MPSCC at present. Therefore, the time–cost–quality–robustness multi-objective optimization of MPSCC will have considerable realistic significance.