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Proactive R&D Project Scheduling with a Bi-Objective Genetic Algoritm

Gündüz Ulusoy and Canan Capa
Sabanci University
Turkey

Abstract

During project execution unforeseen events arise that disrupt plans and budgets and that result in higher costs due to missed due dates and deadlines, resource idleness, higher work-in-process inventory and increased system nervousness due to frequent rescheduling. In this study, we consider the resource constrained multi-project scheduling problem (RCMPSP) with activities being preemptive and subject to generalized precedence relations in a stochastic and dynamic environment for modeling the scheduling of the R&D projects of a leading home appliances company in Turkey. The resources considered are human resources and laboratory equipment. Human resources are multi-skilled resources. The decision environment to be modeled can be described as follows: The R&D Department has a number of R&D projects in progress already scheduled and with resources assigned. A new project arrives and is to be scheduled. The aim is to be able to quote a competitive due date to this new project such that the disturbance to the existing projects is minimal, where the disturbance is related to the changes in the starting and ending times of the activities and projects.

The model is designed as a three-phase model incorporating data mining and project scheduling techniques. These phases are the risk and deviation analysis phase (Phase I); proactive project scheduling with a bi-objective GA (Phase II); reactive project scheduling (Phase III). In this study, we will report only Phase II of the proposed three-phase model. In Phase I, the aim is to predict the deviation level of the newly arrived project and generate percentage resource usage deviation distributions for each activity class in that project using the most known data mining techniques, feature subset selection, clustering and classification. Phase II, which is the main subject of this study, proposes the use of a bi-objective GA for generating a solution robust baseline project schedule by taking into account the possible activity time deviations beforehand and minimizing the completion time for the newly arrived project. The objective functions are the finishing time of the newly arrived project and the solution robustness. Solution robustness is a measure of the difference of the realized schedule during the implementation with the baseline schedule proposed as a result of Phase II. The bi-objective GA used in Phase II is an adopted version of NSGA-II suggested in the literature, which uses an explicit diversity generation procedure along with an elite-preservation procedure. A chromosome is represented with a precedence feasible activity sequence and evaluated based on a set of K realizations reflecting the uncertainty around the activity resource requirements using Phase I of the proposed model. For a given order of activities makespan and solution robustness are assessed through a set of K realizations mimicking the implementation phase, where a realization corresponds to a sample instance obtained by a simulation run using the activities' percentage resource requirement deviation distributions. For this purpose, a heuristic procedure with the objective of minimizing the makespan and solution robustness, expressed in terms of the total sum of absolute deviations value of the robust activity starting times from their counterparts in all K realizations is considered. In each generation of the proposed bi-objective genetic algorithm, non-dominated robust project schedules are obtained. Phase III, the final phase, using dynamic activity lists that reflects the company-specific dynamic environment and re-scheduling rules determined after interviews with the project managers of the firm, revises or re-optimizes the baseline schedule when an unexpected event occurs and enables the project managers to make "what-if analysis" with the help of developed decision support tool and thus to be prepared with better contingency plans.