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Project portfolio management: An integrated method for resource planning and scheduling to minimize planning/scheduling-dependent expenses

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Abstract

It is well known that the progress of *R&D* projects has more and more begun to rely on the availability of individual experts who are generally scarce and expensive. The matrix structure considers periodic staffing of project teams which has been found to be efficient for non-scarce human resources but is impractical for individual experts. Our objective is to develop and evaluate an alternative approach for resource planning and scheduling that might be useful for project portfolio management. The method we suggest is an extension of a recently developed optimization model for a job-shop with several machines and chance-constrained deliveries. Our method determines in advance the hiring and releasing points of individual experts that maximize economic gain subject to chance-constrained delivery commitments. For this purpose, we use a simulation based on a greedy priority dispatching rule as well as a cyclic coordinate descent search-algorithm. A benchmarking of the staffing of project teams and the integrative methods shows that integrated planning and scheduling is a very useful tool for the decision-making process in project portfolio management.

Keywords: Project portfolio; *R&D* projects; Chance-constrained scheduling; Resource planning; Individual experts

1. Introduction

Project Management (*PM*) refers to the creation of a group of individual specialists from different parts of an organization who are brought together for a limited period of time to contribute towards a specific project. Once a project is complete the group is disbanded and its members are assigned to new projects. *PM* is a complex decision making process involving the unrelenting pressures of time and cost. The traditional approach to *PM* is to consider corporate projects as being independent of each other. Yet, the relations between projects within the multiple-project environment have been recognized as a major issue for corporations (Payne, 1995; Ghomi and Ashjari, 2002). Therefore, research in this field has recently shifted towards *Project Portfolio Management* (*PPM*). In order to maintain agility while avoiding wasteful investments, a strong discipline of *PPM* is needed. This requires continuous attention and balancing corporate resources against projects' operational risks. In a multiple-project situation the vast majority of projects share resources with other projects and thus the major issue is to find a way of handling resource scarcity according to the overall strategic direction of the corporation (Cusumano and Nobeoka, 1988). The competition among projects for the allocation of individual experts leads to disagreements (Platje et al., 1994; Payne, 1995; Laslo and Goldberg, 2008) and an intensification of internal lobbying activities (Chi and Nystrom, 1998; Bernasco et al., 1999). Furthermore, attempts to optimize resource allocations are confounded by differences in project activities, due-dates, and the nature of penalties for projects that fail to meet their objectives (Lock, 2000; Meredith and Mantel, 2000). The matrix organization of *R&D* projects results from setting up multi-functional

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teams who are in charge of leading projects with particular objectives. This form enables flexible resource planning that takes into account the availability of scarce resources and the need for special knowledge (Hendriks et al., 1998). Each project is wholly geared towards realizing its delegated objectives through optimal use of allocated resources, especially a skilled workforce (Kerzner, 2000; Bourgeon, 2007). One way to do this is to transfer individuals from their original functional department to the projects for a defined period of time in order to take advantage of their expertise (Katz and Allen, 1985).

PM problems typically consist of resource planning and scheduling decisions. When resource planning decisions are taken, it is extremely important to identify and evaluate the corporate strategic variables in terms of the future posture of the corporate projects with regard to constraints on existing resources (Laslo and Goldberg, 2001). Accelerated technological development strengthens the position of the individual experts who are scarce, expensive and "pampered" resources. Multiple projects contending for limited resources such as individual experts complicates the task of resource planning and scheduling that arises in the daily management of corporations (Vals et al., 2009). An additional important issue that looms high in the management of *R&D* projects is that of uncertainty, ambiguity, and complexity (Pich et al., 2002). In practice, managers frequently create programs and schedules based on the expected values of activity durations. However, many real-world planning and scheduling problems are subject to change, to resources becoming unexpectedly unavailable or tasks taking longer than expected. If these disturbances are significant, then optimal solutions to the original problem may turn out to be deficient in practice, i.e., the probability of completing those projects within a prescribed due-date might be unacceptably low (Williams, 1999; Bregman, 2009; Wu et al., 2009).

Resource planning and scheduling have generally been considered separately in the literature, but the benefits resulting from their integration merit an extensive work in this direction (Tormos et al., 2002). Similarly, new paradigms in project planning and control due to the increased complexity of projects, especially relative to uncertainty, are needed. In particular, *R&D* multi-project corporations need an integrative resource planning and scheduling optimization method that optimizes (minimizes) the total planning/scheduling-dependent expenses subject to its chance-constrained contractual delivery commitments.

The present paper aims at determining such an optimization method by taking into consideration the following factors: (1) the idiosyncrasy of several individual experts as scarce resources; (2) the diverse costs of employing each of the individual experts and the diverse lead-times of their recruitment; (3) the random durations of the project activities executed by the individual experts and other human resources; (4) the typical precedence constraints of project activities (a *Partial Ordered Set* (*POSET*) of activities); (5) the diverse project due-dates and determined chance constraints to accomplish the projects on time; and (6) the diverse delay penalty functions in case of failure to meet the contractual due-dates.

In Section 2 we give an overview of alternative resource planning and scheduling models in the context of *PM* optimization problems and *Job-Shop Problem*s (*JSP*s). The statement of our optimization problem is presented in Section 3. In Section 4 we present a greedy priority dispatching rule that delivers resource scheduling for minimizing definite planning/scheduling-dependent expenses. The integrated solution of the individual experts' planning and scheduling problem via a cyclic coordinate descent search-algorithm, namely "the integrated method", is presented in Section 5. An analysis of virtual implementations on a realistic project portfolio with alternative resource planning and scheduling (the integrated method vs. one of the staffing project team models) is detailed and analyzed in Section 6. On the basis of this analysis, in Section 7 we discuss the implications of implementing the integrated method on both short-term and long-term objectives.

2. Overview: current models for resource planning and scheduling optimization problems

The project scheduling literature largely concentrates on the generation of a precedence and resource feasible schedule that optimizes the scheduling objectives for executing the project. In this literature, the scheduling problems assume a number of projects with several scarce (non) renewable resources at any time and a set of non-preemptive activities, each with a set of predecessors, a set of successors and a set of resource requirements (Pritsker et al., 1969). The *JSP*, where multiple jobs are routed through a workshop with a number of dissimilar machines, is similar to the well-known *Resource-Constrained Project(s) Scheduling Problem* (*RCPSP*). Instead of considering *POSET*s of project activities, the *JSP* is obligated to solving linear ordered sets (of job operations). Both these problems are frequently studied as *NP-hard* optimization problems (Błazewicz et al., 1983). A remarkable improvement of both heuristic and exact solution procedures to solve these problems has been pointed out in several surveys (Ozdamar and Ulusoy, 1995; Herroelen et al., 1998; Kolisch and Hartmann, 1999; Gonik, 1999; Hartmann and Kolisch, 2000; Kolisch and Padman, 2001; Demeulemeester and Herroelen, 2002).

Models with stochastic execution durations necessitate heuristic solution procedures for *RCPSP*/*JSP*, but since these problems are recognized as *NP-hard*, the solution procedures for large models with deterministic execution durations are solved via heuristics as well (Kiran, 1998). The heuristics generally define a scheduling policy that makes decisions at any current decision points throughout the project's life cycle (Igelmund and Radermacher, 1983a,b; Mohring et al., 1984; Mohring et al., 1985). A common decision is to immediately start precedence and