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Optimal Delays, Safe Floats, or Release Dates? Applications of Simulation Optimization in Stochastic Project Scheduling

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Abstract

In the field of project scheduling, the application of activity floats is often the subject of researches that seek to maximize the net present value (NPV) of project networks. However, NPV-based scheduling in stochastic projects may result in a conflict with the primary objective of scheduling, i.e. minimizing the makespan. The main objective of this study is to improve the financial gain while respecting the makespan (i.e. applying safe floats) in stochastic projects. Next, instead of the traditional use of float which prescribes a fixed delay in the start of activity in any condition, we use release dates as the by-product of above-mentioned method to reduce the variation in time and NPV of the project with less computational effort. The project models are simulated in SAS Simulation Studio. Response Surface Methodology (RSM) is used to design the experiments, interpret the results and predict the solution. The focus is on the temporal analysis of stochastic networks, and no resource constraint is considered.

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1. Introduction

Delaying the start of activities postpones the time a cost incurs, and consequently leads to higher net present value of the project which indicates the present value of future money. Other benefits of such delays (e.g. the reduction in holding expenses) may also apply depending on the characteristics of the real life situation. As we will see in the

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third example, the true application of delays reduces the variation in the schedule. Managing a project usually needs coordination among activities, so variation is not very welcomed.

Jorgensen and Wallace (2000) truly discuss that, according to Jensen's inequality, planning methods based on the use of average numbers may lead to underestimation of project costs and durations. So, delaying an activity by a float calculated based on the Pert/CPM procedure may lead to postponement of the project completion. The first two examples, borrowed from the pioneering work of Buss and Rosenblatt (1997) on the subject, will show that NPV-based scheduling may also postpone the project completion. Another issue about NPV-based scheduling is that any activity is a potential candidate for optimizing the objective, even if the activity is critical.

The underlying principle for NPV maximization objective considered here is still the same: delay the expenses as far as possible to capture the time value of money. But we use time-based delays (or safe floats) to remove the possibility of increasing the project duration. In the third example we argue why safe float needs less computational effort. Another issue brought up in that example is how to use safe floats to reduce the variation in the project.

2. Literature Review

The first article on the problem of maximizing the expected present value of Markovian projects-PERT networks with exponentially distributed activities-by Buss and Rosenblatt (1997) brought up an interesting area for the researchers in the field of stochastic project scheduling. The method the authors used (continuous-time Markov decision chain) is still the basis of some recent studies in this field (Creemers, Leus & Lambrecht, 2010; Sobel, Szmerekovsky & Tilson, 2009)

Buss (1995) applied Response Surface Methodology to determine the optimal delays for a stochastic (and not necessarily Markovian) project network. The method we use to calculate safe floats and release dates is the same. The authors are not aware of any other application of designed simulation experiments to optimize project scheduling objectives.

Some researchers studied the float of activities without financial considerations. Tavares, Ferreira and Coelho (1998) set the release date of each activity to its earliest start time plus a fraction of its total float based on the Pert/CPM procedure. Monte Carlo simulation is used to select the optimal fixed fraction for all project activities.

Gong and Rowings (1995) introduce an analytical approach for assessing the change of the expected time of merge events or total project duration with the changes in float use of noncritical activities. They sequentially increase the float of an activity until the disruptive consequence of an activity delay emerges.

Cho and Yum (2004) suggest estimating the criticality index of activity i by means of Monte Carlo simulation, or for a large-sized network, Taguchi orthogonal array experiment. Then, they fit a nonlinear model to predict the criticality index of activity and expected project duration when the mean duration of activity is changed. Delaying an activity has the same effect of change in the mean duration of activity, i.e. it increases the mean completion time of activity while its distribution remains unchanged.

Some address the expected NPV maximization problem for projects with multiple scenarios and their corresponding probabilities for activity durations and cash flows. They suggest an optimal processing time policy for the project activities which prescribes an activity to be started as early as possible in the realized scenario right after (scenario-independent) target processing time (Wiesemann, Kuhn & Rustem, 2010). In this article, the same policy for target release time is advocated, but we do not confine ourselves to finite number of scenarios. There are certainly other valuable researches in stochastic project management, but we are not going to present a thorough literature review on the subject.

3. Theories and Methodology

3.1. Optimal Delays

The concept of optimal delays refers to amount of delays in the start of activities which maximizes the net present value (NPV) of a project. All the cash flows (expenses and incomes) that occur during the execution of activities are discounted towards the start time of the project. The present value of cash flows is calculated using a discount factor