Abstracts

A Methodology for Integrated Risk Management and Proactive Scheduling of Construction Projects

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In demand of and in cooperation with the Belgium Building Research Institute we developed a methodology that helps to build, through risk assessment and proactive/reactive scheduling, a robust project schedule. The methodology is under test on real life construction projects. We document such an application in the last section.

1 Introduction

Construction projects have to be performed in complex dynamic environments that are often characterized by uncertainty and risks. The literature contains ample evidence that many construction projects fail to achieve their time, budget and quality goals ([1],[2]). A study by Maes [10] revealed that inferior planning was the third major cause of company bankruptcies in the Belgian construction industry.

We describe a methodology for risk assessment and proactive/reactive construction project scheduling. Risk management in the construction industry has mostly been used for measuring the impact of potential risks on global project parameters such as time and costs. The literature provides both fuzzy approaches, mixed quantitative/qualitative assessment and risk response methods ([3], [4], [11]). Unlike these approaches, we rely on an integrated methodology that not only allows for uncertainty estimation at the level of the individual project activities, but also uses this input for a proactive scheduling system to generate a robust baseline schedule that is sufficiently protected against anticipated disruptions that may occur during project execution while still guaranteeing a satisfactory project makespan performance.

The methodology relies on a computer supported risk management system that uses a graphical user interface to support project management in the identification, analysis and quantification of the major project risk factors and to derive the probability of their occurrence as well as their impact on the duration of the project activities. Using estimates on the marginal cost of activity starting time disruptions provided by project management, a buffer insertion algorithm is used to generate a proactive baseline schedule that is sufficiently protected against anticipated disruptions that may occur during project execution without compromising on due date performance.

2 Risk assessment

In order to anticipate the risks involved with construction projects it is necessary to quantify them. In practice, software packages ask the project managers to quantify each activity independently. If it is a large project, this is a gigantic work. To minimize this workload we propose a new approach.

We minimize the workload by grouping activities with similar risk profiles. This grouping simplifies the subsequent risk analysis process, which can now be performed at the activity group level rather than at the level of each individual project activity. Secondly, we identify and quantify
the risks on activity group level. The quantification approach is somewhat similar to the minimalist first pass approach of Chapman and Ward [5]. Similar to theirs, our approach expects project management to provide the probability of occurrence and the impact of the risk factors on the activities of an activity group under a best case scenario and a worst case scenario. This results in probability density functions for each risk associated with an activity group. Finally, the probability density functions of the impacts for all detected risks are projected on the individual project activities thus yielding the activity duration distribution functions (Triangular or Beta).

This projection is the key to the reusability of the risk assessments at the level of the activity groups. Using the characteristics of the risk impact densities and probability, risk assessments and/or risk data coming from project records and distributions for project activities can be calculated and entered in a risk management database.

Other than the duration distributions, the activity weights are defined. The weights reflect the scheduling flexibility of the activities in the groups and will be used by the robust project scheduling procedures. For the technical details of the approach we refer to Schatteman et. al. ([9]).

3 The robust project scheduling system

The robust project scheduling system we propose relies on the generation of a robust project baseline schedule that anticipates identified risks and that is sufficiently protected against distortions that may occur during actual project execution. The system takes as input the data generated during the risk identification and quantification process described in the previous section.

The robust baseline schedule is generated by introducing time buffers in a precedence and resource feasible project schedule. Time buffering is one of the possible techniques for generating proactive project schedules ([7],[12],[6]).

We use the bi-criteria objective of maximizing the timely project completion probability and minimizing the weighted sum of the expected absolute deviation in activity starting times.

Excellent results have been obtained by the Starting Time Criticality (STC) heuristic, that exploits the information generated by the risk assessment procedure described earlier.

4 Applying the framework to a real-life project

We document the application of our risk management and proactive/reactive scheduling framework to a real-life project in the Belgian construction industry. The housing project involved the construction of a five-story apartment building in Brussels.

We used the initial project network developed by the project team and their activity time estimates as input. During the risk assessment procedure, use could be made of the risk management database maintained at the BBRI, which contained risk data obtained on a similar construction project.

Four procedures were used to construct a baseline schedule.

In a first analysis we take the four generated baseline schedules as input and submit them to disruptions in simulation runs of the project, using the estimated activity distributions and imposing a reactive scheduling procedure at schedule breakage that applies a robust parallel generation scheme based on a priority list that orders the activities in non-decreasing order of their starting times in the baseline schedule ([12]). The requested service level for each of the four schedules is set to 99%.

A second analysis is performed upon completion of the project. At the time when the actual disturbances that occurred during the execution of the project were all known, we confronted the
four baseline schedules with the actual schedule disruptions. Each time a schedule was disrupted, the same reactive procedure as used in the first analysis, was used to repair the schedule.

The validation of the procedures revealed that the schedule generated by MS Project® sets a complete unrealistic planned project delivery date, which was violated by more than four months due to numerous schedule breakages. The schedule generated by ProChain® using a 50 % buffer sizing rule, included too much protection and was subjected to numerous disruptions, resulting into high instability costs. Using the sum of squares buffer sizing rule does away with the unacceptable large target buffers but was still outperformed by the STC schedule on both makespan performance and stability cost.

References


