Omega 39 (2011) 416–426

Contents lists available at ScienceDirect

Omega

journal homepage: www.elsevier.com/locate/omega

On the dynamic use of project performance and schedule risk information during project tracking

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ARTICLE INFO

Article history:
Received 20 November 2009
Accepted 24 September 2010
Processed by B. Lev
Available online 16 October 2010

Keywords:
Project management

ABSTRACT

Project scheduling, risk analysis and project tracking are key parameters to a project's success or failure. Research on the relative sensitivity of project activities during the project scheduling phase as well as research on project performance measurement during project progress have been published throughout the academic literature and the popular press. Obviously, the interest in activity sensitivity information and project performance measurement from both the academics and the practitioners lies in the need to focus a project manager's attention on those activities that influence the performance of the project. When management has knowledge about the current project performance and has a certain feeling of the relative sensitivity of the various project activities on the project objective, a better management focus and a more accurate response during project tracking should positively contribute to the overall performance of the project.

In this article, two alternative project tracking methods to detect project problems are presented and their efficiency on the quality of corrective actions to bring the project back on track is measured and evaluated. More precisely, a bottom-up and a top-down project tracking approach within a corrective action framework is applied on a large and diverse set of fictitious projects that are subject to Monte-Carlo simulations to simulate fictitious project progress under uncertainty. The top-down tracking approach relies on state-of-the-art earned value management performance metrics, while the bottom-up tracking mechanism makes use of the well-known schedule risk analysis method.

A computational experiment shows that a top-down project tracking approach is highly efficient for project networks with a serial activity structure while a bottom-up approach performs better in a parallel structured project network. Moreover, it will also be shown that dynamic thresholds to trigger corrective actions, which gradually increase or decrease the project manager's attention along the project progress, outperform the static thresholds for both tracking approaches.

1. Introduction

Constructing a project baseline schedule (*project scheduling*), assessing a project's risk (*risk analysis*) and measuring the current performance of a project in progress (*project tracking* or *monitoring*) are crucial steps throughout the life of a project. The project manager uses the project schedule to help plan, execute and control project activities and to track and monitor the progress of the project. A major component of a project schedule is a work breakdown structure (WBS) which will play a central role throughout the project tracking methods discussed in this paper. However, the basic critical path method (CPM) schedules, or its often more sophisticated extensions, are nothing more but just the starting point for schedule management. Information about the sensitivity of the various parts of the schedule, quantified in schedule risk numbers or of a more qualitative nature, offers an extra opportunity to increase the accuracy of the schedules and might serve as an additional tool to improve the project tracking process. Consequently, project scheduling and tracking tools and techniques should give project managers access to real-time data including activity sensitivity, project completion percentages, actuals and forecasts on time and cost in order to gain a better understanding of the overall project performance and to be able to make faster and more effective corrective decisions. All this requires understandable project performance dashboards that visualize important key project metrics that quickly reveal information on time and cost deviations at the project level (top WBS level) or the activity level (bottom WBS level). During project tracking, the project manager should use all available information

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doi:10.1016/j.omega.2010.09.006

and should set thresholds on the project or lower WBS levels that act as warning signals during the project's progress to indicate when corrective actions are necessary to bring the project back on track.

This paper tests two alternative project tracking methods by using two types of dynamic information during project progress to improve corrective action decisions. Information on the sensitivity of individual project activities obtained through schedule risk analysis (SRA) as well as dynamic performance information obtained through earned value management (EVM) will be dynamically used to steer the corrective action decision making process. Throughout this paper, the primary focus is on the *time* measurement of a project in progress. However, cost information and its performance measurement will be used in case this information is needed to measure time performance and to predict the final project duration.

The outline of this paper can be summarized along the following lines. Section 2 gives a brief overview on project time performance and time sensitivity. Section 3 introduces the two alternative project tracking methods that will be used throughout this paper. In section 4, the test setting and computational results of the simulation study are discussed in detail. Section 5 draws overall conclusions and highlights future research avenues.

2. Literature study

2.1. Earned value management

Earned value management systems have been set up to deal with the complex task of controlling and adjusting the baseline project schedule during execution, taking into account project scope, timed delivery and total project budget. It is a well known and generally accepted management system that integrates cost, schedule and technical performance and allows the calculation of cost and schedule variances and performance indices and forecasts of project cost and schedule duration. The EVM method provides early indications of project performance to highlight the need for eventual corrective actions. For an overview on EVM, see Fleming and Koppelman [1].

Since its introduction, EVM has been the subject to a vast amount of research both in academic as well in more practical settings. However, throughout the years, the research on EVM has been mainly cost driven (see, e.g. the EVM bibliography of Dr. David S. Christenson[1]). Recently, the time dimension has received a renewed and increasing research attention, stimulated by three papers that present three different EVM methods to predict the final duration of a project. The planned value method (PVM) [2] and the earned duration method (EDM) [3] rely on the traditional EVM key parameters and measure a project's time progress in a monetary unit (schedule variance (SV)) or in a unitless index (schedule performance index (SPI)). Lipke [4] introduced the earned schedule method (ESM) as a response of the unreliable behavior of the classic schedule performance index (SPI) in the later stages of late projects used in the two previous methods, and calculated two alternative schedule performance measures (referred to as SV(t) and SPI(t)) that are directly expressed in time units. Since then, various authors have validated the new earned schedule method on both fictitious and real life project data. Many of these research validations have been published in the non-academic journals such as The Measurable News, Project and Profits and CrossTalk and can be found at www.earnedschedule.com. Vandevoorde and Venhoucke [5] were the first authors that extensively compared the three time prediction methods and tested them to a simple one activity project and a real life data set. They summarized the often confusing terminology used in the earned value/schedule literature. Venhoucke and Vandevoorde [6] have validated the new technique on a wide and diverse set of fictitious project networks, and concluded that the earned schedule method indeed performs on average better than the planned value method and earned duration method on forecasting the duration of a project. Finally, Lipke et al. [7] have used data from 12 real life projects to improve the capability of project managers for making informed decisions by providing a reliable forecasting method of the final cost and duration.

In the remaining sections of this paper, the standard EVM abbreviations will be used, as summarized along the following lines:

AT	Actual time
PV	Planned value
BAC	Budget at completion
AC	Actual cost
EV	Earned value
ES	Earned schedule
CV	Cost variance (EV-AC)
CPI	Cost performance index (EV/AC)
SV	Schedule variance (EV-PV)
SPI	Schedule performance index (EV/PV)
SV(t)	Alternative schedule variance (ES-AT)
SPI(t)	Alternative schedule performance index (ES/AT)

2.2. Schedule risk analysis

Since the introduction of the well-known PERT in the late 1950's in project scheduling, the research on measuring a project's sensitivity has increasingly received attention from both practitioners and academics. Motivated by the common knowledge that the traditional critical path analysis gives an optimistic project duration estimate (see, e.g. [8–10] and many others), measuring the project sensitivity and the ability to forecast the final duration during its execution have become key parameters for project managers. Schedule risk analysis [11] has been discussed widely in the literature as an easy tool to detect the sensitivity of individual activities of a project. The project schedule is often a deterministic view on the future, and will seldom contain some practical value and correct estimates of activity durations and costs. However, using stochastic durations and costs with the traditional Monte-Carlo simulation allows to detect a sensitivity value for each activity, and eventually a completion time distribution for the overall project duration. Despite the many often diverse research outputs, shortcomings are mentioned from different research angles and a lot of confusions on advantages and/or disadvantages have been mentioned while only partial answers on the shortcomings have been reported (for an overview, see, e.g. [12]). Partial answers are given by Vanhoucke [13] who has evaluated four commonly used sensitivity measures on their ability to improve the schedule performance of a project when used in a dynamic corrective action decision making tracking approach.

In the remaining sections of this paper, four sensitivity measures from the literature that will be used during the computational experiment will be abbreviated as follows:

CI	Criticality index
SI	Significance index
CRI	Cruciality index
SSI	Schedule sensitivity index

[1] www.suu.edu/faculty/christensend/ev-bib.html