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Relevance Of Historical-Data Based Activity Scheduling And Risk Mitigation Model

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ABSTRACT

Scheduling is one of the most vibrant research areas in management due to its wide application in many work system. Ironically, the statistics of project success suggests that most projects still fail due to numerous uncertainties in scheduling which lead to inability to accurately predict project completion time. This presents possibly a unique opportunity for substantial improvement. In this paper the authors offer their perspective about the challenge that the project scheduling research community is facing today. They look at project duration prediction from three perspectives; finding realistic set of input data for estimating activity duration, developing and applying more accurate project activity duration estimating models and reliable contingency action plan to handle eventualities arising from the inevitable working environmental and technical uncertainties during project execution. Although these views are certainly not unique, they may provide a new direction for researchers and techniques for more effective time management in risky business environment.

Keywords: *Risk; Uncertainty; Scheduling; Historical –Data; Management*

1. INTRODUCTION

The Standish group report (StandishGroup, 2015) that 29% of software development projects within the United State are successful, 52% are challenged and 19% failed. Other individual researchers have been able to link project failure with planning and scheduling (Aziz, 2013). Project planning and scheduling is simply the process of identifying activities, and when each is to be performed in order to complete the project at an expected time. A recurring problem in scheduling involves inability to accurately predict project completion time. This is daunting to project scheduling researchers and practitioners as project planning techniques are used across work systems by managers such as corporate presidents, agency directors, line managers, school administrators, movie producers, farm managers, or wherever on-time completion is a must.

There seems to be a great gap between existing research and what is needed to fix project duration prediction problem in practice. In this paper our observation on the challenges and opportunities in project scheduling research are provided. We elaborate on the nature of uncertainty in project scheduling, the current state-of-the-art and problems associated with existing uncertainty treatment techniques. We then conclude with a summary and suggestions for improvement.

2. LITERATURE REVIEW

The Project Management Institute (PMI) in their Project Management Body of Knowledge (PMI, 2013) defined the term “project” as “a temporary endeavor undertaken to create a unique product, service, or result”. Projects can be described as one of the oldest endeavors of man around the world; which is evident in great designs, constructions, and transformation around us. At the heart of project management is scheduling. This aims at developing a plan for a set of activities that comprise a project according to a set of precedence and other constraints to achieve an objective.

The first scientific scheduling model was an algorithm developed by a research team led by Morgan R. Walker of Du Pont company and James E. Kelly, of Remington Rand Univac. This is known as Critical Path Method (CPM). The goal of CPM is to determine project duration subject to zero-lag finish start precedence constraints when project activity information is known (such as duration, cost etc.) and resources are unlimited. The model defines the start, finish and amount of time an activity may be delayed from its early start without delaying the expected project completion date. More advanced models provide schedules which satisfy some resource constraint problems (Brucker, et al., 1999). Schedule generally serves as a means for managers; to allocate human, material or physical resources to activities, plan internal and external supporting activities such as supplies, maintenance, procurement etc., to communicate with other stakeholders, yardstick for cash flow projection and finally to set a project completion date. Accurate schedule development is therefore important when on-time project completion is a must for management success.

However, uncertainty in the work environment, policy directions and especially in developing economies affect effective execution of project activities which lead to overrun of predicted project completion time and in turn drastically affect project cost and quality. Such situation was considered by the authors of Program Evaluation and Review Technique (PERT), in their effort to solve the slipping schedule problem in the creation of the Polaris weapon system for the Navy. They implicitly assume beta distribution is suitable for analyzing possible uncertainty in activity duration. Due to lack of historical project data at the time of the model development and difficulty in estimating the shape parameters of beta distribution, the authors further assumed that; expert can accurately estimate duration parameters of the distribution, the standard deviation of the distribution is one-sixth of the range and linear approximation of the mean is acceptable (Littlefield & Randolph, 1987) in order to arrive at a weighted average approximation for the mean activity duration and a variance conditioned on the range.

Since the model publication over six decades ago, it has been widely criticized based on its underlying assumptions and inability to accurately predict project duration. Many authors have suggested technical improvements of the weighted average model. The first group of authors approve beta distribution but condemns the restrictions on its shape parameter (Shankar & Sireesha, 2010). To eliminate PERT underlying assumptions relating to beta distribution, a second group of authors suggest alternative distributions such as; triangular, lognormal etc.(Abdelkader and Al-Ohali, 2013). However, to accurately use any of these models, observed distribution of activity duration must be as assumed in the model development and expert elicited values must be realistic. A few other authors propose discretization method which simply represents any continuous random variable (such as activity duration) with a finite set of fractile points and associated probabilities. Additional difficulty here, is that fractile points and associated probability (weight) have to be pre-specified before an expert is asked to elicit values corresponding to them (Lau & Somarajan, 1995).

These critics reveal that fundamentals of PERT's activity duration estimation postulation: that actually observed duration may agree with well thought out plan (most of the time estimate); fall below plan (optimistic) or exceed plan (pessimistic) is not theoretically untrue but the choice of statistical distributions, manner of estimating parameter values and derivation of duration from parameter values are unjustified.

2.1. Alternatives of PERT Paradigm

Other techniques which account for uncertainty in project duration prediction include;

Monte Carlo Simulation (MCS): The first step in MCS is to define the probability distribution of activity durations. PERT-beta distribution or any of the earlier proposed distributions may be chosen. During the simulation, parameters of selected distribution are randomly generated and then used to determine expected project duration using the conventional CPM approach. The process is repeated until required number of simulations is reached. The outputs of the analysis are a probability distribution of the total project duration. Although MCS is considered more detailed than PERT, it uses what is fundamentally a similar plan of attack.

Fuzzy based Scheduling (FBS): For novel situations like the PERT Polaris weapon system project where no prior information is available about the project, advocates of the fuzzy approach argue that probability distributions may not be appropriate for modeling uncertainty. They propose fuzzy PERT which make use of membership functions, based on possibility theory (Ock & Han, 2010).

Critical Chain Scheduling (CCS):Other authors against PERT paradigm cantered around the critical chain (CCS) methodology which account for uncertainty by allocating redundant time to represent possible variation in activity duration, this requires no distribution. In Goldratt CC Scheduling, the project schedule is built with target duration estimates based on a 50% confidence level and the remaining 50% associated with each activity is shifted to the end of the longest chain which determines the project lead time. The main conclusion that can be drawn from the studies on CCS is the non-scientific implementation of buffer (Ash & Pittman, 2008).

Nonetheless, even with accurate activity duration estimation models, actual completion duration may not be guaranteed due to the nature of risk events. Risk events during activity execution are caused by uncertain factors internal or external to the project. Internal factors are due to actions or inactions of project manager/ organization while external factors are without fault or negligence typically attributable to unforeseen/uncontrollable situations. In a bid to consider possible occurrence of risk events during execution, some other attempts have been developed to improve project duration prediction accuracy.

2.2. Proactive Approach Scheduling

Proactive scheduling focuses on constructing predictive schedules that use statistical knowledge of uncertain event with the aim of increasing schedule robustness. A schedule is considered to be robust if it can absorb any disruptions without affecting planned activities while maintaining performance (Lambrechts, et al., 2011). Proactive schedule may be developed using redundancy-based techniques, probabilistic techniques, and contingent/policy-based techniques. Redundancy-based techniques allocate extra resources and/or time in the schedule. The central idea is to provide each activity with extra time to execute so that some level of uncertainty can be absorbed and project objective is achieved. This is similar to the critical chain methodology except for intelligent insertion of extra time. Probabilistic techniques do not explicitly insert redundancy, rather, use schedule that has the greatest probability of attaining a certain performance while contingent techniques are based on the use of multiple schedules (or schedule fragments) which optimally respond to anticipated events(Wu et al., 2009).

2.3. Ranking Indices Approach

The risk management professionals on the other hand consider identifying and mitigating causes of risk a better approach to improve project duration prediction accuracy. The proposed indices for ranking activities or risk events requiring risk mitigation effort (Creemers et al., 2014). These are however also based on simulation study of possible risk scenarios.

3. MISSING ISSUES

Perhaps, the existing problems may be due to some prevailing conditions in the project management environment.

One of such conditions is the lack of project historical data or poor documentation of lesson learned (Yogi, 2011). This may be drawn from the failure of well-planned and managed projects which may not be considered totally unique; such as iridium network project, Denver International Airport project, (Shenhar & Dvir, 2007). Historical data is described as a form of empirical information that is quantified, edited and documented. With increasing cost and schedule overruns, fueled by the inability to explain causes, historical project database management system has been identified as a vital resource for effective review and validation of project estimation process (Elliot, 2005). Truly, experiences are best guide, but time fades memories. In a study by Meyer and Vissre (Meyer and Visser, 2006), duration data for similar project activities was obtained from historical records of a metal refinery to predict project duration. They concluded that more accurate total project duration was obtained with the use of historical records. Existing expert or simulation based activity duration estimation models do not necessarily replicate project reality; though such may be useful for novel project situations. At the pace project-based management style is gaining acceptance in most corporate work system; the creation of activity historical database with information on causes of schedule slippage may ameliorate this project duration prediction problem and add value to scheduling decisions in risky project environment.

Another related problem is the existing chaos in the risk management research community, leaving no clear distinction between two very important terminologies; risk and uncertainty. Uncertainty is solely described in terms of probability distribution representing the likelihood that unknown quantity falls within a given range of values. In some cases, it is described as either aleatoric or epistemic. Aleatoric has to do with chance or stochastic nature of event. It is a state where the outcome of an event is not known with certainty even though the rule governing occurrence of event is known with certainty. For example, a fair dice thrown once (event) has six possible outcomes, which cannot be known with certainty but in terms of their probability which is one-sixth. The event is known and defined, but the outcome is uncertain because it is variable. This is also known as variability. Epistemic (also known as ambiguity) on the other hand is due to incomplete information or lack of knowledge. There is no prior information about event and may be subjectively quantified by an assessor (Sanderson 2012). Risk on the other hand is traditionally viewed as; 'unwanted' or undesired. This view is reflected in its definition in standard dictionary and some technical documents. For example, the Oxford Dictionary of English (2015), defined risk as "chance of failure". This definition characterizes risk as likelihood associated with a negative event such as machine breakdown, defective design, absence of key work personnel, late delivery of material, unfavorable weather condition etc. However, other definition propagated in project managment (PMI, 2013) and many other technical literature (Renn 2005) describe risk as uncertain event or condition that, if it occurs has a positive or negative effect on project objectives such as scope, schedule, cost, or quality". Based on the two definitions, some authors quantitatively define risk as the probability that some expected target value will be exceeded (Park, 2007) while others choose to define it as the product of the probability of risky event and the associated consequence (Corotis & Hammel, 2010; Pinto, 2012).Similarly, while some authors describe uncertainty only in terms of ambiguity and variability as risk , others choose that the totality of these two states of variability and ambiguity makes up uncertainty(Koleczko, 2012). Some other authors (Perminova, et al., 2008; Pinto 2012) choose to put a distinctive perspective. They view risk and uncertainty as cause and consequence. They described uncertainty as a cause factor which has two possible effect which may be positive (opportunity) or negative (risk). This lack of consensus in the definition and interpretation of risk and uncertainty may hamper a scientific treatment of risk events in scheduling.

4. CONCLUSION AND RECOMMENDATION

The dilemma posed by project completion time and cost over-runs is daunting to, not only project managers, but also to the scientific community. There are about three prongs of the problem situation here. The first is the difficulty of developing and applying more accurate project activity duration estimating models. The second, which is closely related to the first, is the hitch associated with finding realistic set of input data for estimating activity duration. The third is lack of reliable contingency action plan to handle eventualities arising from the inevitable working environmental and technical uncertainties during project execution.

A good estimating model is usually a statistical distribution which adequately replicates the behavior of well executed work system of identical/similar projects in the environment. In this context, valid input data to such statistical model ought to be historical data of related projects. Such data may have to be more than just values of duration per project activity but also observed causes of deviation or over-run from previous plans. Consequently, to solve the problems of project over-runs from plan, appropriate statistical distributions have to be selected for estimating model construction to be combined with quality historical data of activity duration and causes of over-runs. The former may improve accuracy of estimates while the latter may be useful for risk mitigation plan development.

Addressing these issues, adopting PERT paradigm is the problem of our on-going research.

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