A simulation model for strategic management process of software projects

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ABSTRACT

In this study, a simulation model for the strategic management process of software development projects is presented. The proposed model simulates the implications of strategic decisions on factors such as cost, risk, budget and schedule of software projects. The main advantage of the proposed model is that it provides an integrated framework wherein risk management, cost estimation, and project management planning for the strategic management process of software development projects are linked. The results of the simulation of the project management planning determine the budget and schedule required for a project. Different strategic management decisions pose different sets of risks, each of which require different cost commitments. Hence, each strategic decision requires a project management plan with its own unique budget and schedule of software development. Thus, the simulation model estimates the risk and cost under different strategic decisions and maps them according to the project management plans. Therefore, the proposed integrated framework helps identify the best strategic option for the development and management of software projects. The proposed simulation model is nonspecific because it contains generic plug and play components that facilitate the use of any set of risk assessment, cost estimation models and project management tools. Therefore, it provides a flexible solution to software organisations and managers of software development projects. The simulation model is applied to a case study, which showed the effect of different strategic decisions on the risk and cost of the different phases of software development and ultimately on the budget and schedule required to complete the project. It therefore provides critical insights in identifying the best strategy for the development of software projects.

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1. Introduction

As the complexity of software development projects grows, new solutions are needed for the development and management of software projects. Today's turbulent technological and market environment, fuelled by innovative technological advancements and market competition, has added new dimensions to the management and development of software projects. Therefore, decision making in software development has become more strategic than ever. Consequently, organisations and managers of software development projects not only have to consider project development activities, but also decide which strategic decisions are critical for the effective and efficient development and management of software projects. Therefore, the strategic management of software projects is no longer a choice but a necessity.

Software organisations have to make strategic decisions regarding the strategic management of software projects, each of which has a varying degree of impact on the project parameters during different phases of the project. Strategic decision making occurs in the early stages of software projects and, at that time, complete information about projects is not known. Therefore, modelling and simulation of the strategic management process provide an alternative to strategic decision making. Formulation of strategies is the main responsibility of management and project managers execute and implement these strategies. Therefore, formulation of successful strategic management plans requires the collaboration of business and project managers (Jacques and Andre, 2007).

The strategic management process is about designing and undertaking decisions of strategic importance in order to manage and control strategic project parameters. If the implications of different strategic decisions on strategic project parameters are not properly understood, undesirable management and development options may be selected. Therefore, the scope of strategic management focuses on the overall management of projects and defines and sets the direction of the project development activities (Papadakis and Barwise, 1997) while project management ensures the implementation of the strategic decisions (Jacques and Andre, 2007). Therefore, projects must have strategic management plans that are mapped to the project management plans (Shenhar,

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1999). For example, an organisation makes a strategic decision to develop and test a specific software project internally. However, it could alternatively plan to develop the software project internally but outsource the testing phase. These two strategies have different sets of risks that require different cost commitments. Hence, both strategies would have different implications on the project management plan with their own unique costs to the budget and schedule.

When multiple strategic options exist for a particular software development project, quantifying the parameters of strategic importance using simulations of the strategic decisions highlights the implications of each strategic decision on the project management plan. Therefore, simulation of the strategic management process requires estimating the strategic importance of each parameter for each strategic decision and understanding how these quantified parameters shape project management plans. Simulation models help to understand the particular features of a process, which allows better management and control of these features. Simulation and modelling for software development processes are utilised in a variety of ways, including strategic management of software projects (Kellner et al., 1999). Simulation models provide ways to examine the consequences of strategic decisions on strategic project parameters and project management plans and therefore help software organisations select the best strategic decision that suits their resources, budget, risk tolerance and management style. Therefore, simulation of strategic management process supports decision making by identifying those strategic decisions that are beneficial for the development of software projects. Therefore, rather than implementing strategic management decisions directly in real software development plans, simulations reduce the risk of making wrong decisions (de Juan et al., 1999; Law and Kelton, 1991).

The field of software engineering is rapidly expanding, but it has not been able to benefit from the research that has taken place in the business and strategic management domains, which has created a need to establish links between software engineering and strategic management (Kakihara, 2006). Software projects can benefit from strategic management practices that address the challenges of rapid expansion of software development activities. Some research works study the development of software projects from the business perspective of strategic management (Cusumano, 2004; Cusumano and Selby, 1995; MacCormack, 2001). While, some studies are conducted from the software perspective by applying strategic management practices to software development projects (Kiper and Feather, 2005; Kakihara, 2006; Williford and Chang, 1999). However, research material for the strategic management of software development projects is scarce in the field of software engineering. This limited knowledge of strategic management impacts the development of software projects in the wake of a rapidly changing technological and market environment. In addition, a framework of strategic management for software projects, which can map strategic decisions with parameters of strategic importance and connect them with project management plans, has not yet been developed.

This research presents a simulation model for the strategic management of software development projects. The model emphasises the effects of strategic decisions on strategic parameters of software projects and explains how these affect project management plans. Hence, it is an integrated framework of strategic management, which links the strategic decisions with project parameters and project management plans. The proposed simulation model is generic in nature because it consists of generic components with well-defined interfaces. Therefore, any estimation and assessment models and project management planning tools can be used in the simulation. Furthermore, the research work presents a MATLAB©-based simulation application, which implements the proposed simulation model for software projects and facilitates a better understanding of the integrated simulation framework for the strategic management of software development projects.

This research paper is organised into the following sections. Section 2 discusses current software development and strategic management process models for software projects and explains how such processes can be further improved. Section 3 presents the modelling requirements and discusses strategic parameters along with project development phases that are adopted for constructing the proposed strategic management model for software development projects. Further, it explains the modelling techniques to choose the best technique for the proposed simulation model. Section 4 presents the integrated framework of the strategic management process simulation model. Section 5 discusses the construction details of the proposed simulation model and presents the risk assessment, risk management and cost estimation models and project management tool that were used in the construction of the simulation model. It further presents a MATLAB© based simulation application, which implements the proposed model of the strategic management process. Section 6 lists the procedures used to validate the proposed simulation model and the simulation application. Section 7 discusses a case-study using the simulation application and shows how strategic decisions are transformed into quantified parameters through simulations and how these parameters are mapped to project management plans. Lastly, Section 8 presents the conclusion to this research paper.

2. Process models for software projects

Development and management processes for software projects are defined as a set of activities, methods, and practices adopted for the effective and efficient development and management of software projects. Therefore, simulation models of software processes simulate different features of the development stages and the management options for software projects. This section explores existing simulation models of software development and strategic management process models, which provide a foundation for further research and development.

2.1. Software development process models

The groundwork for the modelling and simulation of software development processes was carried out by Morecroft and Abdel-Hamid (1983), who proposed a generic software development process simulation model based on the System Dynamics (SD) modelling technique, which was further developed by Abdel-Hamid and Madnick (1989). Madachay (1994) constructed a SD-based simulation model that studied the effects of performance inspections during the software development process.

Kouskouras and Georgiou (2007) proposed a simulation model based on the Discrete Event Simulation (DES) technique to simulate different phases of the waterfall model (Boehm, 1988) for software development projects where each development phase transitions to the next phase in an orderly sequence. More recently, hybrid simulation models that integrate SD and DES have been proposed; for example, Ruiz et al.'s (2004) model simulates the Capability Maturity Model (CMM) for software development projects.

2.2. Strategic management process models

Kiper and Feather (2005) presented a model based on the analysis of risk and cost to support strategic decision making in software development projects. They discussed two approaches by which data could be incorporated early in the project lifecycle; these approaches involve the use of either expert opinion or historical data from similar projects. Decision making in the model is