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Dynamic planning and control methodology for strategic and operational construction project management

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Abstract

This paper introduces the system's perspective of the dynamic planning and control methodology (DPM), aimed to support both the strategic and the operational aspects of project management. For this objective, a new modeling framework that integrates system dynamics and network-based tools is presented in this paper. The proposed framework adopts system dynamics as a core simulation engine for strategic project management and network-based tools as a wrap layer for operational project management. To implement the DPM framework, a web-based system has been developed within a collaborative environment. The developed system provides great support to both the strategic and operational aspects of project management by integrating familiar network concepts with system dynamics to analyze the overall strategic and operational project performance.
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1. Introduction

Construction projects are inherently complex and dynamic, involving multiple feedback processes and nonlinear relationships [1]. While problems encountered during construction are fundamentally dynamic, they have been treated statically within a partial view of a project [2]. As a result, schedule delays and cost overruns are common in construction projects in spite of advances in construction equipment and management techniques [3]. To overcome these chronic symptoms, enormous efforts have been devoted to the planning and control aspects of construction management.

A widely adopted approach for planning and control in the A/E/C industry is the use of network-based tools, such as Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT), and Earned Value Method (EVM). However, because these tools inherently utilize a static approach that may provide users with unrealistic estimations, they may ignore prevalent multiple feedback processes and nonlinear relationships of a project [2] or be inadequate to the challenge of today's dynamic projects [4]. On the other hand, simulation-based tools have been developed to address uncertain characteristics of construction. A major approach applied to simulation-based tools is discrete-event simulation, which mainly focuses on the operational aspects of construction projects, by introducing stochastic queuing processes. Although there are examples where simulation-based tools have been used effectively to solve operational construction problems, they have experienced only limited adoption by the A/E/C industry for the strategic aspects of construction management [5]. Possible explanations for this limited adoption could be because of its difficult development process and narrow focus on the operational level.

Prior to weighing the pros and cons of existing tools, it is important to address which characteristics should be

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incorporated in a project management system in order to deal with complex and uncertain construction projects both at the strategic and operational levels. Construction can be defined as process-based work that is performed at unfixed locations by a temporary alliance among multiple organizations [6]. These features, along with the fact that construction is carried out in open environments, make human responses to environmental and managerial decisions highly unpredictable [3]. Suppose that overtime is adopted to compensate for a delayed schedule. Although overtime can compensate for lost time in a delayed schedule, it can increase a worker's fatigue and, consequently, deteriorate a worker's productivity in the long-term. In this context, it is necessary for the project manager to have a holistic and strategic view of a project, such as how overtime should be applied, while keeping in mind the threshold of the worker's fatigue which will make overtime counterproductive.

Because of these factors, strategic project management has been recognized as a critical issue for project success [7]. Strategic project management makes decisions up front during the design phase of a project, and then guides consequent operational decisions. In this way, these operational decisions can be consistent with the longer term impacts on project performance [2]. Implementing strategic project management lets project managers see not only the relationships of different parties and work sequences in their entirety, but also the impact of how one event or decision could affect overall project performance. After strategic project management is undertaken, operational project management can help administer a detailed operational analysis with the guidance of the strategies set forward at the strategic project management stage.

Currently, existing tools may have difficulty handling the dynamic characteristics of both strategic and operational project management, due to the static approach of network-based tools and the operational aspects of simulation-based tools. The goal of this paper is to introduce a tool for a new integrated network-based simulation approach, dynamic planning and control methodology (DPM), which encompasses both the strategic and the operational aspects of project management based on the identified dynamics of a project.

The following section presents the adopted research methodology. The importance of the integration of strategic project management with operational project management is discussed, followed by a description of a new hybrid network-based simulation approach as an alternative to existing tools. In addition, a web-based system, which implements the proposed framework, is presented within a collaboration scheme. Lastly, the application of the newly developed system to a project in a real world scenario is introduced.

2. Strategic and operational project management

Based on the primary concentration on what to manage, project management can be differentiated by two major approaches: strategic project management and operational project management. Strategic project management is differentiated from organizational (i.e., company) strategic management in that it involves determining the fit of specific projects in achieving the main strategy of a company [2]. Strategic project management narrows down and takes into account an individual project's strategy, which may be centered on systems design and provides a basis for determining major targets [7]. Therefore, strategic project management can be defined as the management actions that are incorporated into a project in order to meet a strategic objective of a project by adjusting not only time, cost, and resources, but also the target. On the other hand, operational project management can be defined as the management actions incorporated to meet a project's target by adjusting time, cost, and resources. In other words, it can be represented as the steps taken to achieve a defined project strategy.

Thus, one of the major differences between strategic and operational project management is that operational project management does not include changing the target. Therefore, in order to make an operational decision, a set of activities from a project is extracted, with the assumption that they can be discrete and that well-defined information about time, cost, and resources are available. Then, a discrete analysis is conducted to identify the effects of varying time, cost, and resources in order to achieve the defined targets. This is the domain that the traditional project management tools have focused on [7]. However, in order for successful implementation of strategic project management, a set of activities and parties involved in a project cannot be treated separately. Rather, they should be identified as continuous elements of a project. In this way, a strategic decision can be made by considering the decision impact on a project as a whole, not just as the sum of the impact on individual parts of the project.

2.1. Integration of strategic and operational project management

Both strategic project management and operational project management have their own advantages and disadvantages. For instance, implementing strategic project management helps a project manager make good decisions within the overall performance behavior and pattern of a project. But strategic project management lacks the capability to quantify detailed impacts. On the other hand, operational implementing project management is able to quantify detailed impacts of a project, but the given targets as well as information about time, cost, and resources could be easily changed, for example, by an owner's change request. Thus, making good assumptions for operational project management is unpredictable and particularly, dependent on strategic project management.

However, in order to effectively manage a project, both strategic and operational approaches are required, simulta-

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