Critical Path Method Implementation Drawbacks: A Discussion Using Action Theory

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The Critical Path Method has enjoyed a wide acceptance by the upper management of construction companies and in construction management academia. This popularity has not been matched by its embrace at the field management level. Explanations for this paradox have been independent of each other. This article applies Action Theory to provide cohesion to traditional explanations, as well to gain more insight into the reasons for this behavior. CPM is identified as a prototypical application of the Deliberative Action model, with the intrinsic limitations of this model. Possible improvements are focused on the integration of features akin to the Situated Action model, which is more responsive to the dynamics of a construction project.

Key Words: Critical Path Method, Action Theory, Project Management.

Introduction

The Critical Path Method (CPM) is one of the most ubiquitous formal methods for the management of construction projects, and is part of virtually every Construction Management (CM) baccalaureate program. Despite its popularity, many construction schedules developed using this method sit idle in the project's field office. Understanding this paradox is of utmost significance for construction management. If the reasons for this lack of use and even open animosity towards CPM work plans are understood, it would lead to better field management. On the other hand, if this method has fundamental drawbacks, they should be identified and fixed. If the drawbacks are so significant that they are impossible to fix, then the method should be left behind in favor of alternative techniques such as Lean Construction (Koskela and Howell, 2002). The status quo, however, should be unacceptable. It does not make sense to keep developing plans that will not be used.

The traditional explanations for the lack of use of CPM by field management lack a unifying theoretical basis, and each one is disconnected from the others. In contrast, this problem can be coherently explained by a model of Action Theory. Using principles directly derived from theory is uncommon in the construction industry, and have not been used to frame the problem at hand.

Objective

This paper offers a case study of the use of theory to analyze a significant problem in the management of construction projects, namely the lack of use of plans developed using the Critical Path Method. By applying theory to solve a practical and relevant problem, this article provides a template for further applications of theory to relevant issues in construction management. A comprehensive analysis and detailed recommendations for the improvement of the CPM is beyond the scope and length afforded by this article. Its objective, as much as outlining a solution to the problem, is establishing a point of departure for the wider use of current theories in the context of Construction Management.

The Critical Path Method

The Critical Path Method (CPM) is widely used in the construction industry to create the formal work plan for a project. Many owners and government agencies mandate its use by project contractors as a requisite for disbursing

the first progress payment. Courts are requiring the use of CPM to prove project delays (Loulakis and McLaughlin, 2005). CPM is a standard topic in construction management programs. Moreover, it is the engine behind most computer software packages for planning, such as SureTrak™, Primavera Project Planner™, and Microsoft Project™.

Having been developed to manage construction projects and used in many industries, this method is covered by virtually all construction academic programs. The American Council for Construction Education (ACCE) in its Document 103 stipulates 3 semester hours (or 4 quarter hours) of Planning and Scheduling as a requisite for accreditation (ACCE, 2008). This strong endorsement implies that the merits of CPM for project planning and control are beyond any doubt.

Implementation problems

CPM has never achieved the degree of success as a field control tool to match its runaway popularity in construction academia and the upper management levels of the industry. As Docherty remarked, "it is quite common to find the formal plans prepared at the firm/project level decorating the project management office walls on site. Execution proper is governed by informal short – term planning performed by site/work management, at times totally disallowing the formal plans." (Docherty, 1972). At the company/project level, "the CPM information system is formal and has a limited effect on on-site execution. It functions mainly to describe the historical developments and the current status. At the site/work level there is a system of informal information and decision – making, mainly short – term that dictates execution on site." (Laufer and Tucker, 1987). Surveys have found that "[The main concern of top management] concerning CPM was that construction personnel who must do the work, or supervise it, are not 'really using' the system." (Davis, 1974).

Even in the cases where CPM is claimed to be successfully used, updating the plan has been reported as a considerably difficulty. Jaafari remarks that "large amount of efforts are required to re-plan and redraw the network each time it is updated" (Jaafari ,1986) . The substantial level of effort required to update a CPM plan has been also researched by Laufer and Cohenca, who found that for a $20 million construction project lasting eighteen months, three man-months were invested in planning prior to the onset of construction, while control during the course of the construction required fifteen man-months (Laufer and Cohenca, 1986). Arditi and Koseoglu point out that updating the plan is regarded by many field personnel as a retrospective exercise instead of a forward-looking action, resulting in an inconsistent level of effort for this task (Arditi and Koseoglu,1983)

Traditional Explanations for CPM Implementation Drawbacks

There have been many attempts to explain the implementation problems of CPM schedules. Some authors have been candid to express their perplexity with the paradox of the lack of use of this method as Birrell when he wrote that "the failure of the majority [of practitioners to use CPM or PERT…exposes that there is some fundamental failure in the CPM/PERT technique" (Birrell, 1980).

Traditional explanations for the lack of field use of the CPM can be divided into two categories for the purposes of this paper. One category consists of explanations which exonerate the method itself from any fundamental fault and instead blame its users for the method's problems. A second category of explanations look into issues that are not under the users' control, and instead are the result of misguided practices.

In the first category, the most common line of reasoning posits that a better job in teaching and explaining the method and its implementation tools (i.e., software) would solve the current implementation problems of the CPM. Birrell succinctly expressed this explanation: "The reasons for CPM/Pert limited use seem to be a failure to appreciate its simplicity and a misconception that computers and scheduling specialists are necessary for its use" (Birrell, 1980). Robinson added the challenge of educating CPM users: "The misconceptions surrounding CPM and computers –and the lack of education about the methods – may be two of many reasons why the new method is not being used as much as it could be in the building industry" (Robinson,1965).

A variant to the claimed lack of understanding of the method is that implementation problems are derived from poor schedules whose lack of quality lead to their rejection by field management. For example, R. Lewton, a construction manager for Weitz Co., IA remarked that "among the young guys, computers have made it easy to slap together something that looks right, but there is a thought process that must be involved, and it is hard to tell in many contemporary schedules if the thinking happened or not" (Korman, 2004).

The second category of explanations identified here examines reasons beyond user training and effort. This rationale is loosely centered on the idea that the current development and use of CPM schedules overlook the original intent of the method or are developed without seeking the advice from key personnel. These lines of reasoning are more nuanced than those faulting the method's users. They include concerns about the planning horizon (Laufer and Howell, 1993), the use of a Work Breakdown Structure (Huber and Raiser, 2003), and an emphasis on the "what" instead of the "how" which makes most plans of little value for field management (Halpin, 1993).

Both categories of explanations have some degree of merits. However, although each one can make a valid point, they are disconnected from each other and do not attempt to detect any fundamental limitations of the method. Would CPM's shortcomings disappear if each one of these issues was corrected? The line of thought criticizing the lack of training and attention cannot be disproved. It is always possible to improve anyone's education, and for that reason, this rationale will not be explored here. This article hypothesizes that all current explanations provide relief for the symptoms and not to the illness of the problem. As discussed in the following sections, principles of Action Theory reveal that the CPM demands inconsistent or even impossible behavior from field personnel. These principles are compatible with traditional explanations, as discussed in the sections ahead.

Action Theory

In its most simple account, Action Theory can be described as a branch of philosophy that examines the behavior of an individual agent as the result of its interaction with a situation (Johnston et al., 2005). In the case of CPM, the agent can be the project manager, and the situation can be the project environment. Its two main models carry implications for the formulation and application of techniques centered on human activity, of which project planning and execution is only a small fraction. Action Theory is an integral part of many modern aspects of artificial intelligence, sociology, psychology, linguistics and other areas concerned with human action (Agre, 1997).

There are two competing models in Action Theory. The Deliberative Action model posits that action is the result of a plan. The Situated Action model considers that action is based on broad goals with a limited planning timeframe. The Deliberative Action model has been increasingly challenged by its Situated Action counterpart. The following sections discuss in more detail these two models and their implications for CPM.

The Deliberative Action Model

The Deliberative Action model asserts that project execution should be dictated by a comprehensive plan resulting from a deliberate intellectual effort to develop and use a symbolic model of the project (Johnston and Brennan, 1996). A main goal of actors implementing this plan is to avoid divergences from the prescribed course of action, and to feed information to the symbolic model so that it can forecast deviations or change the original project plan.

The Deliberative Action model has a huge (albeit implicit) influence over standard, traditional project planning and control. The common understanding of planning and execution by most construction managers is indeed that planning should be a prerequisite for action. The plan is seen as the control mechanism that governs execution of the steps required to complete a project in the same way that a computer program can govern the sequence of calculations performed by a computer. Without a program, a computer will not produce any meaningful output; without a plan, actions cannot result in a built project.

The sequence of events in the planning process begins, according to this model, when a person or group (an "agent") is put in charge of developing the plan. The agent collects all possible information about the project and constructs a symbolic model of the world in which the project will be performed. In the context of CPM planning, this model is

the activity network, and the agent is the CPM scheduler. The agent then operates this model and simulates an acceptable sequence of actions to achieve the desired goal, on the assumption that the optimum output on the model can be translated into equivalent actions on the real world. The output from this virtual model – the CPM schedule in the context of this discussion – serves as the command mechanism for the execution of all actions leading to the project completion (Agre and Chapman, 1990).

As the plan execution progresses, there will be differences between the conditions modeled in the plan and reality, which will be detected and reported by the execution actors using means predetermined by the agent. Weekly progress reports or CPM schedule update reports are examples of such means in a construction project. This information is translated by the agent into data compatible with the planning model that follows, in parallel, the field actions. By simulating the remaining actions on the model, the agent can decide whether to continue with the current plan, or to plan new actions to accommodate the sensed world data. (Johnston and Brennan, 1996).

The actors implementing the plan are visualized as having a subordinate role, if any, in the decision-making process of deciding the steps to reach the desired goal. Successfully executing a project is synonymous with successfully following the project plan. *Control* consists primarily of measuring regularly project performance to identify variances from the plan. For example, the Project Management Institute asserts in its PMBOK that "to the extent that significant variances are observed…, adjustments to the plan are made by repeating the appropriate the appropriate planning processes" (PMI, 2004).

The Situated Action Model

The Situated Action model has come to the fore of Action Theory in the last decades, challenging many of the premises of the Deliberative Action model. The fundamental insight of the Situated Action model is that every person (or "agent") is immersed in an environment. This limits the agent's ability to perceive reality and consequently, to plan any action (Johnston and Brennan, 1996).

The vast majority of actions taken by an agent follow a stable routine, according to the Situated Action model. No one could function if each step in everyday life would need to be planned and evaluated. It follows that the more structured, or "routinized", an environment can be, the more time actors can devote to the performance of actions meaningful to the pursuit of their goal (Johnston et al., 2005, using U.K. grammar *routinised*).It follows that planning an action should be an exceptional event, only becoming necessary when there is a break down of an agent's routine. The term break down is taken in the very general sense discussed by Heidegger (Heidegger, 1962) when he points out that routine artifacts, cultural or physical, are "invisible" to their user until a disturbance makes them "visible."

Lastly, the Situated Action model posits that actions should be informed, but not dictated, by the project plan. Agre and Chapman call this distinction "plans-as-programs" in the Deliberative Action model, and "plans as-communications" in the Situated Action model. (Agre and Chapman, 1990)

An Action Theory Perspective of CPM Implementation Problems

CPM closely follows the deliberative action model, since it attempts to create a virtual, equivalent and complete model of the project to perform. The implementation problems of the CPM can be explained coherently and robustly by examining the assumptions of this method using Action Theory. Four essential aspects are discussed here: the indirect nature of the information to update a schedule, the contradictions in the role of plans in the Deliberative Action model, the role of instructions in the implementation of the plan, and the view of the world as a hostile environment. Although other secondary issues could be added to this discussion, these four aspects are at the heart of the issues at hand.

Updating

The drawbacks of CPM are visible at execution time. Natural variations in the assumptions made about productivity, resources, weather and similar factors make inevitable that the plan becomes increasingly removed from the actual circumstances in the field. The gap between plan and reality is supposed to be resolved by updating the schedule by providing new input to the model that reflects field conditions. But, updating is not a simple proposition. There must be a substantial extrapolation between the information provided by field personnel and the input ready to be processed by the model. For example, a common consequence of a reduction in the number of electricians in one week is that not all of them will be back the next week, since they will be tied working in another project. It is true that an experienced scheduler may revise the remaining activities requiring of electricians so that their duration reflects the fewer number of electricians, but this would be the result of the programmer's experience, not directly of the update information. The input ultimately going into the plan update is the result of more or less arbitrary assumptions made by few, or even a single, individuals (Johnston and Brennan, 1996).

The reported difficulties in updating a CPM schedule are, therefore, not the result of incompetence or lack of attention as much as the fallout of the many extrapolations that a scheduler must make in the office from the field data.

Role of plans

The role of plans is central to the shortcoming s of the CPM. As previously discussed, this method attempts to thoroughly "think" in advance the project execution and the result of this process is the plan. A plan can be changed to reflect reported field conditions, but the basic paradigm of the Deliberative Action model underlying the CPM is that performing an action should be always the result of a preceding plan (Agre, 1997).

In the Deliberative Action model, project execution is intended to follow the plan, and control is primarily an effort to detect and avoid deviations from this plan. This model demands compliance to the plan as a requisite for control, which leads to an absurd dilemma. Virtually no good project manager regards the project plan as the absolute factor controlling performance. However, each call deviating from the letter of the approved plan is taken at the project manager's peril. If the unplanned measure does not work, the manager will be blamed for deviating from the official plan. If this officially approved plan is followed and it does not work, it will be the manager's fault to have followed it instead of fixing the problem. This reasoning applies directly to the case of a project using CPM, as any experienced project manager could attest.

Role of instructions. Plans are implemented through instructions that can be verbal, written or graphical. Instructions are the interface between the agent intentions set forth in a plan and the actors in charge of executing the plan. Instructions are intrinsically imperfect, and trying to follow any set of instructions can lead to absurd situations (Suchman, 1987).

The deliberative model and therefore the CPM rely on the premise that instructions will be followed and that instructions will not be followed. It would be easy to assert that knowing when instructions should not be obeyed is the hallmark of any good manager. While it is true that good managers realize the absurdity of blindly following a set of instructions, it is also true that they will be held liable for breaking the plan if the project is unsuccessful. Recognizing the indexicality (i.e., dependence on the agent's context) of instructions should be an essential component of any construction planning system.

Nature of the world. The deliberative model regards the world as "fundamentally hostile, in the sense that rational action requires extensive, even exhaustive, attempts to anticipate difficulties" (Agre, 1997). This is such a widespread sentiment in the construction industry that it takes effort to realize that by far, the world is familiar, harmonious and stable. This is the essential fact that allows the accomplishing of any objective, since the amount of possible ways that the world can change at any moment is nearly infinite, especially if the assumption is that the change would be for the worst. Since only a fraction of negative possible outcomes can be anticipated by any planning and control system, it follows that all planning and control systems are sooner or later doomed to fail. The enemy, according to this siege war reasoning, will sooner or later find the unguarded section of the wall or will figure a Trojan horse.

The inevitable fallout of this vision is that CPM systems attempt to detect and react to negative events, but do not have a concerted way to improve from positive events. For example, a standard cost control system will flag activities over budget, but will not flag activities under budget. The reactive nature of current management seeps into most input forms, system reports and contractual relations. Moreover, this logic leads to a confrontational work environment that most people would like to avoid.

Potential Improvements to the CPM

The issues discussed above can be used to frame the improvements that would benefit the implementation of the plans developed by the CPM. These improvements are derived from principles of Action Theory, and particularly from its Situated Action model.

Limiting the scope and detail of the schedule

The Situated Action model makes clear that a detailed plan for the entire project is intrinsically futile. As Laufer and Howell state, most project managers believe that "a plan's time horizon should be maximal and a plan should be comprehensive, detailed and complete" (Laufer and Howell, 1993). Even without considering the Situated Action model, it seems logical to keep the level of detail in the plan proportional to the information at hand. A CPM schedule would be easier to handle and more responsive to reality if it would define in broad terms activities starting in the far future ("far future" being defined by the uncertainty of each particular project), and then define in increasingly finer level of detail activities as their start times approach.

Involving field personnel

CPM schedules tend to be imposed on the field management. This is a natural fallout of the Deliberative Action model, since the development and execution of the plan are considered as separate issues. The primary role of foremen and other field personnel is the implementation of the plan, not its development.. For example, Kratt describes best practices in planning and states that a weekly meeting includes a presentation of "a look-ahead prepared by cost and schedule engineers and delivered to the foremen for review well ahead of schedule." (Kratt, 1989). Not only are field personnel expertise and requirements frequently ignored by the formal planners sitting at the central office, but accepting these plans is mandatory rather than voluntary (Ramanujan et al., 1986). A true participation of field personnel in the planning of a project improves the quality of the plan and commits the field management to its execution.

Expanding the granularity of the schedule. As a result of attempting to be comprehensive, a CPM schedule is too detailed for activities in the far future and too broad for the management needs for the near future. Once more, a central command is inadequate for the nimble requirements of project execution. A CPM schedule should serve as the basis for a detailed plan of immediate tasks such as specifying the rooms to finish next week. These tasks can be developed and controlled by the field management in parallel to the official CPM schedule. Unfortunately, most current CPM software packages do not allow an easy way to communicate useful activity information such as float time for a field to-do list, or the uploading of the results of such to-do list to update the schedule.

Changing the role of the plan. Perhaps the most important insight offered by Action Theory is that plans should inform, not dictate, management decisions. This statement can seem to be so obvious as to be trivial, but it is revolutionary. PMI's PMBOK, for example, states that "corrective action is anything done to bring expected project performance in line with the plan" (PMI, 2004) It also indicates that the project plan "should be expected to change over time", but as the result of a formal process beyond the field management purview. Beckman goes as far as stating that "the government's representative must challenge every proposed change against the CPM and force the contractor to use his schedule." (Beckman, 1999). In such world, a project's CPM schedule is the law of the land, not a recommendation, insofar as the sequence of its activities.

Conclusion

Analyzing CPM through Action Theory, and particularly using its two models begs the question of how can anyone expect the field management of a construction project to use this method more than of why it is that field management does not use it. Many expectations about the use of CPM are based on faulty assumptions. As discussed here, a comprehensive activity schedule runs against the indexicality of the decisions that must be constantly made by field management. Furthermore, no one is in a better position to judge the best next step in a project than its field management, whose position cannot be matched by any expert working with necessarily imperfect update information.

The most perplexing fact of project administration may be the enormous weight given to the approved activity schedule, at least on paper. This document is intended to trump the expertise of field management, while at the same time, field management is supposed to know the point at which following it would be nonsensical. These contradictions in the actions expected from field management make obvious that it cannot favor an imposed CPM schedule. This paper discussed ways to improve these shortcomings, which are independent of the skill level of CPM users. The problems addressed here would not be resolved by more or better training, since they are intrinsic to the method. Too much time and effort have been invested to prove this important point.

The scope of this article is limited to a discussion of CPM drawbacks, and not to a substantive discussion of alternative planning techniques (among other reasons, it would be impossible to address this logical next step within the length limits required for this conference paper). However, it is imperative to add that the evolving management area of Lean Construction (Koskela and Howell, 2002) has been developed with a keen awareness of the limitations discussed here. This awareness is particularly visible in many aspects of the Last Planner System™ (Ballard 2000), which is the most widely known Lean Construction application. This management system follows many Situated Action theory principles, and is the best example to date of a rational approach to planning that is not based on the CPM. The author discusses elsewhere the implementation of alternative methods (Senior, 2007, Senior, 2004).

The term theory has a negative undertone for some professionals and even academics in the construction industry, as if it was in opposition to practical, factual or real. Such attitude is a big mistake. The lack of a theoretical foundation underpinning construction management practices has been pointed out and long lamented by distinguished scholars (e.g., Koskela and Howell, 2002, Koskela, 2000, Halpin, 1993). The absence of a reference framework for the explicit and implicit rationale underlying project management techniques has resulted in mostly Byzantine discussions about the merits and drawbacks of its current methods, since there is no consistency in what attributes to look for to assess them. This paper shows an example of how the larger context afforded by the use of theory can result in a clearer view of a construction management problem.

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