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COMPARISON OF TRADITIONAL PROJECT MANAGEMENT TECHNIQUES AND CRITICAL CHAIN PROJECT MANAGEMENT FOR MANAGEMENT OF INFORMATION TECHNOLOGY AND INFORMATION SYSTEM PROJECTS

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Abstract

This proposal concentrates on applications of project management models and techniques in new product development practices (NPD) in IT. After analyzing implementation of various models and techniques in IT, detailed research was performed for NPD practices in IT. Specific techniques were compared through a questionnaire and real world applications. Results revealed limitations of traditional techniques such as (PERT/CPM) and Critical Chain Project Management's (CCPM) potential of overcoming these limitations. However, depending on CCPM's some shortcomings recommendations to improve CCPM were also proposed.

Keywords: Project Management, IT, CCPM, Software Development

BİLİŞİM TEKNOLOJİLERİ VE BİLİŞİM SİSTEMLERİ PROJELERİ YÖNETİMİNDE GELENEKSEL PROJE YÖNETİMİ TEKNİKLERİ VE KRİTİK ZİNCİR PROJE YÖNETİMİ TEKNİĞİNİN KARŞILAŞTIRILMASI

Özet

Bu çalışma Bilgi Teknolojileri (BT) projelerinde yeni ürün geliştirme uygulamaları için kullanılan proje yönetimi modelleri ve teknikleri üzerine odaklanmaktadır. Çalışmanın kapsamı BT'de kullanılan çeşitli proje yönetimi modelleri ve tekniklerine ait uygulamaların analiz edilerek BT için yeni ürün geliştirme süreçleriyle ilgili detaylı bir araştırma yapılmasıdır. Bu bağlamda belirli teknikler bir anket ve gerçekleştirilmiş olan uygulamalar aracılığıyla karşılaştırmalı olarak analiz edilmiş ve PERT/CPM gibi geleneksel proje yönetimi tekniklerinin kısıtları belirlenmiştir. Bulgular neticesinde Kritik Zincir Proje Yönetiminin (Critical Chain Project Management-CCPM) bu geleneksel yöntemlerin kısıtlarının üstesinden gelme potansiyeline sahip olduğuna ulaşılmış fakat bu tekniğin de birtakım kısıtları tespit edilmiştir. CCPM'in belirlenen gelişmeye açık yönleri ve kısıtlarına dayanarak bu tekniğin geliştirilmesiyle ilgili bazı öneriler sunulmuştur.

Anahtar Kelimeler: Proje Yönetimi, BT, CCPM, Yazılım Geliştirme

INTRODUCTION

Design, development and deployment of new and complex systems never attempted before are among the most challenging engineering activities that have been performed over the past few decades. The essence of project management emerged from the requirement for new methods of planning, organizing, and controlling activities that are instrumental in completing the development of these systems within reasonable schedules and budgets (Shtub, Bard and Globerson, 2005). Traditional project management techniques such as PERT/CPM focus on ordering tasks and scheduling in a rigid manner without considering resource allocation issues. When the organization is performing multiple projects at the same time, resource management cannot be provided with these techniques in a multi-project environment. These traditional methods require allocation of safety times for each task which causes bad multi-tasking, student syndrome, delays and ignorance of priorities, and waste of time and resources (Pai, 2014:15).

Broadly speaking, the objective of this research is to investigate how the development of new products never attempted before are managed in various IT organizations. In accordance with the gathered results efficiency improvement strategies associated with the possible improvement areas for project management of software new product development were recommended at the end of the study.

Data and information about existing project management models and techniques in the literature were acquired through books, e-resources, journals, reports and releases. Comprehensive information about new product development projects and supportive case studies analyzing real world implementations were obtained by the same means.

Evaluation of cases and the process of data collection contributed to gain deep insight into project management practices of new product development projects in IT and software engineering and revealed some particular common problems encountered in project management activities. This provided support in the case of questionnaire design which seeks out existing project management practices of companies, their limitations and potential improvement areas. Results revealed an obvious trend of limitations on traditional techniques that are commonly used, and this gave insight into selecting case studies associated with overcoming these limitations. The major goal of companies in real world applications was to overcome the shortcomings of traditional techniques which encouraged them using CCPM, an advanced technique. Although CCPM was found to be a successful technique in general, it can be more beneficial by filling its potential with some improvements which are discussed in this study.

THEORETICAL BACKGROUND

Project management and new product development

Project management deals with activities with the aim of achieving a set of goals. Risks in project management environments stem from high degree of uncertainty. Most projects, particularly new product development ones, have lots of risks because of uncertainties emerging from incorrect and insufficient data, forecasting errors, scheduling and cost related factors, organizational structure and political environment. Hence, new product development projects characteristically have uncertainties due to their usage of new technologies, methods, techniques and processes (Shtub, Bard and Globerson, 2005).

Buyukozkan and Feyzioglu (2004:151) presents Goldenberg, Lehmann and Mazursky's (2001) research to state that failures in NPD projects and their relevant costs are significantly high which makes NPD a more complex process. There is a huge gap between the information in hand and the information essential for task completion which generates the uncertainty.

Uncertainty management by contributing towards decreasing risks in NPD projects is important for accomplishment.

Traditional project management techniques (PERT/CPM)

Program Evaluation and Review Technique (PERT) applies statistical handling over a probable range of activity duration by providing a three time probabilistic analysis model. Pessimistic (p), optimistic (0) and most likely (m) time durations are used by the model and the expected time of the activity is calculated by using the normal distribution of durations. However, there are some factors that limit effectiveness of PERT. First of all, time estimation is done based on the project manager's own subjective views, and excessive effort is needed when estimating the duration of each task separately. Moreover, commonly there is a tendency to undervalue time estimations which bear failures in meeting the deadline. Deadline problems necessitate enhancement in allocated resources which results in budget overruns (Burke, 2003). Huang et al. (2012:381) state that bad human behaviour increases the lead time of projects and multitasking as well. Depending on their experience, people with the knowledge of safety time have a tendency to start the work late and misuse the safety time. Additionally, multiple projects are initiated without any prioritization, resulting pressure on resources.

Critical Path Method (CPM) is suitable for task scheduling of projects. Tasks that are linked on a project network are components of a work breakdown structure, and a project network graph demonstrates the order of tasks and their dependencies. For the estimation of task durations certainty and accuracy is critical, however when the level of uncertainty between task dependencies increase, models lose their reality. (SE Project, 2004). Depending on the fact that during the project execution there may be changes on critical paths, network diagrams should be examined regularly and monitored for the shift of critical path. This results in additional changes in scheduling and reallocation issues (Stelth and Roy, 2009).

Critical chain project management

Goldratt (1997) introduced Critical Chain Project Management (CCPM) as an application of Theory of Constraints (TOC) to project management and project scheduling. For managing a single particular project, the unique constraint is the longest chain in the project network that considers activity priority and resource dependencies. When managing projects sharing a common resource pool, (multi-project environments) this constraint is the resource that obstructs the early finishing of projects (Ghaffari and Emsley, 2015:44). According to Goldratt's approach as cited in Verhoef (2013) initial step of TOC is the definition of the existing constraint. Then after enhancing the capacity of this constraint by using available resources improvement actions go on till the constraint is not a limiting cause. Following this step the same circle starts again by the identification of the other constraint.

PERT and CPM estimates time of each activity with including provision for contingencies. In critical chain approach all these separate activity buffers become a project buffer. When total contingency reserves are taken away from each activity and accumulated in a project buffer, the time necessary to finish the project can be decreased (Steyn, 2002:77). Using buffers as an instantaneous and direct mechanism helps monitoring project schedule and controlling (Leach, 1999:39). As team members deal with activity padding less and task accomplishment more, total project time is significantly decreased. Even though the delivery date cannot be met (as it is the case most of the time), total impact on project duration is decreased as a result of the downstream aggregated buffer (Shtub, Bard and Globerson, 2005).

Comparison of CCPM and traditional project management techniques

Blackstone, Cox and Schleier (2009:7030) stated that the estimation method of project task times is an important factor in analyzing the reasons of failed projects in traditional project

management. Task estimation is done subjectively depending on factors that may postpone the task and allocated resources. Besides, student syndrome, Parkinson's law, task convergence, resource dependencies and planning to start date factors also affect being behind schedule. When there is a certain amount of time allocated for particular tasks, employees have a tendency of starting late which causes safety times in every task to be wasted which is known as student syndrome.

However, CCPM offers the benefits of following mechanisms for dealing with project delays: First of all, safety in tasks is removed and critical chain is determined by considering resource dependencies. Besides, buffers are used for time reductions and buffer usage provides a mechanism for controlling the progress of project by project buffer charts (Verhoef, 2013). Moreover, CCPM by defending the priority of project release according to an identified resource that behaves like drum maintains the work flow in multi-project environment. This causes the inhibition of too many projects with extreme multitasking and being on schedule. In addition to benefits of CCPM over traditional techniques explained above, Leach (1999:46) presents that project team behaviour is supported by reporting of early finish of activities. Pai (2014:16) reported that after the application of CCPM, implementation cases stated that 95% on-time and on-budget delivery was achieved. Moreover, lead-times decreased by 69%, cycle times by 66%, whereas due date performance increased by 60% and revenue/throughput by 68% on average.

PROJECT MANAGEMENT FOR IT NEW PRODUCT DEVELOPMENT

Based on the theoretical background presented above, cases from real world applications are analyzed to evaluate the drawbacks of existing project management practices of companies, to investigate their CCPM implementation procedure and to test real benefits acquired compared to what literature offers.

Case study_1

A company that is a designer and manufacturer of mobile phones is analyzed for its project management approach in this study. The company operates in Shanghai, China and deals with innovative product development that requires software development. Since traditional project management techniques such as PERT/CPM were not capable of handling iterative product development processes, the company implemented a dynamic development process model for managing overlapped iterative product development (Lin et al., 2008:379).

The model considered the dynamics of rework probability and activity duration simulates upstream evaluation and its impact on downstream rework by system dynamics approach. Different overlapping strategies for three kinds of NPD projects were tested and project performances in terms of product lead times were observed. After the application of the model, the average product lead time decreased by 30%. The model is successful for handling complex and iterative product development, and modelling NPD software projects which require considering the effects iterations and overlapping when uncertainties are high. However non existence of resource allocation mechanisms limits conducting projects as multiple projects level (Lin et al., 2008:390).

Case study_2

Abbott Diagnostic Division (ADD) because of long delivery times and scheduling drawbacks started to use CCPM approach. Buffers were sized by 50%, and when duration of a task was less than the 50% estimate, savings were added to project buffer, and when duration was more, time was driven from buffer. Additionally, resource allocation at multi-project level was provided. Buffers were controlled and monitored each week, and cultural and behavioural changes that CCPM requires were practiced thorough training and workshops. Employees

needed to work against project deadlines rather than task due dates which resulted employee resistance because of the too much effort. As projects were very complex, planning with buffers and project network creation was difficult. However, as a result of accurate resource allocation and buffer management policies, the company obtained reduced delivery date (Brandt, 2003:22).

Case study_3

Segway Inc. implemented a hybrid approach by using agile project management approach and CCPM together. The product that company was developing was an innovative product with software which increased uncertainties. The project had a highly indefinite scope which was very complex and lead to difficulties in critical chain. Nevertheless, the utilization of agile principles contributed complementing CCPM. An effective buffer management, a high level of collaboration in the case of story and schedule creations provided 18 months of development time which was considerably short for such a complicated project (Gelbwaks, 2003:27).

Case study_4

This case study examines the application of CCPM by Bosch CCTV Eindhoven in Netherlands. The development division of the company designs video security systems such as cameras and video recording products. As a result of technological advancements, the company was dealing with complex requirements for new product development projects, and so as to avoid project delays, increase visibility, obtain realistic schedules and to increase number of projects done by same resources, the company implemented CCPM. The utilization of buffer trend charts and weekly meetings for controlling the buffer status enabled the project team to take preventative actions depending on the buffer status. However buffer sizing issues were problematic. Depletion of buffers and early consumption was observed, which reflected the need for larger buffers. Although the buffers were inserted with regard to absorb uncertainties such as scope changes and risks, size of buffers were not capable by doing so. Changes in scope and unforeseen tasks caused delays in the schedule. However, delays in projects were shorter than before (Dilmaghani, 2008).

Case study_5

This research is about the effectiveness of CCPM deployed at the Air Force Flight Test Center (AFFTC) in California. Since aerospace combat systems were being developed, the environment was highly volatile which caused failure of project management approaches. An uncertain environment, risks and characteristics of projects caused increase in costs, delays in due dates and low performance. Other problems that project management were encountering were inefficiency in resource usage, decrease in customer satisfaction and inadequate monitoring and reporting. In order to solve the problem, the Flight Test Center implemented CCPM in 2001 and Smith (2012) stated that AFFTC gained enhancement in scheduling and resource allocation after the implementation. Traditional techniques that the company were using before were compared with CCPM, and specifically overall effectiveness of CPM and CCPM projects were evaluated with a cost-benefit analysis. However, incorporating CCPM was challenging at AFFTC in terms of employee resistance. So as to improve acceptance, significant leadership attempts were put on to encourage the CCPM, and full acceptance is still need to be realized.

Case study_6

This case is about CCPM implementation at Synergies Technologies Group which conducts over 200 projects at the same time in a very complex environment due to fast technological changes and uncertainties. For this industry, the recent major performance

indicator was on-time delivery and company performance was evaluated based on on-time delivery. Although Synergies was a very successful company, they were not able to manage finishing projects on time around two years ago. The company did not have a robust project management system which resulted in low visibility, poor coordination and ambiguous priority issues of projects. While CCPM was being implemented in the organization cultural challenges were taken into account by providing support and excellent training. For instance, meeting for a critical chain action plan were contributed communication for challenges and some of the activities were outsourced at first so as to encourage a new philosophy by decreasing workload of dense fields. Synergies is now capable of handling over 200 projects in multi-projects manner and achieving on-time delivery (Pai, 2014:18).

Table 1. Summary of cases analyzed

Company Name	**Implementation Procedure**			**Benefits**
	Reasons for Implementation	**Applied techniques**	**Challenges in implementation**	
Company A	•PERT/CPM insufficiency for iterative product development	A dynamic development process model	•No resouce allocation mechanisms •Not suitable for multi-project environment	•%30 decrease in product lead time •Success in dealing with complex and iterative development
Abbott Diagnostic Division	•Long delivery times •Scheduling problems	CCPM with %50 buffer sizing	•Employee resistance •Difficulties in buffer planning •Difficulties in network creation	•Reduction in delivery dates •Multi-project pipelining •Resource efficiency
Segway Inc.	•High level of uncertainty due to product structure	CCPM+ Agile Approach	•Changes of specifications	•High level of collaboration •18 months of development time (significantly short)
Bosch CCTV	•Project delays •Low visibility •Unrealistic schedules •Need for multi-project pipelining	CCPM	•Problems in buffer sizing •Insufficient buffer size •Multi-project pipelining cannot be implemented properly due to complexities	•Shorter delays in projects
Air Force Flight Test Center (AFFTC)	•Project delays •Low performance •Failure of exisiting PM practices-high costs •Inefficiency in resource usage and monitoring •Decrease in customer satisfaction	CCPM	•Employee resistance •Fully acceptance for the CCPM approach cannot be provided	•Cost effectiveness •Improved schedule •Improved overall performance
Synergies Tech. Group	•Project delays •Low visibility •Low level of coordination •Need for multi-project pipelining	CCPM	•Employee resistance	•On-time delivery •Capability of conducting multiple projects concurrently

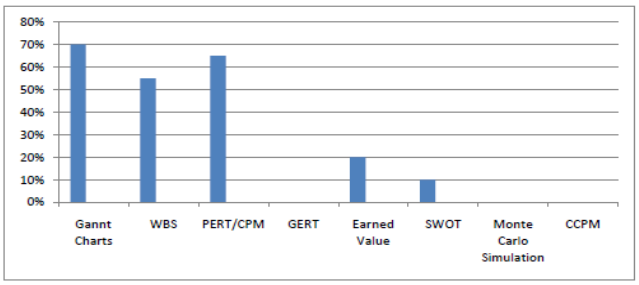
SURVEY DESIGN AND IMPLEMENTATIONS

In order to support findings from the analysis of the case studies above and to investigate project management practices of companies conducting NPD projects in detail, a questionnaire was prepared so as to get supportive data. The questionnaire contained 21 questions, 2 of them were designed in multiple choice formats and for 19 questions a 5-point Likert scale was used. The questions were about project management techniques that the

company was using and approximate number of projects over a 5 year period in which the company failed to satisfy their deadlines. Further companies were asked to rate a set of drawback factors that they experience in their processes and to score a set of activities that may improve efficiency of project management performance.

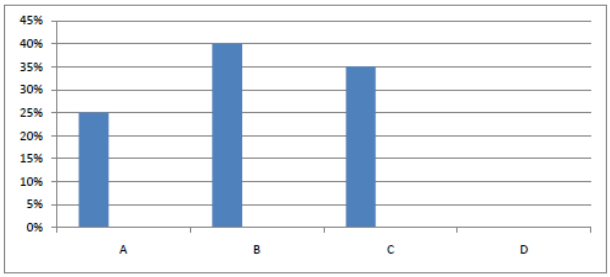
The purpose of asking project performers to score between a set of factors was to obtain a response tendency for each improvement factor by measuring the average of response values. The questionnaire was sent to 30 overseas companies and 18 responses were obtained, reflecting a 60% response rate. We asked the companies which project management techniques they used; according to the results in Figure 1, the most widely used project management techniques were Gantt charts among respondents. Approximately 65% of respondents reported that they used PERT/CPM for their projects and around 55% of project performers reported the utilization of WBS. None of the respondents claimed that they used Graphical Evaluation and Review (GERT), Monte Carlo Simulation and CCPM in their practices.

Figure 1. Project management techniques in use



Another question was about percentage of projects with delays, and the categorization was done as follows:

Figure 2. Approximate percentages of projects with delays in deadline over a five year period



A: 75%-less than 100%
B: 50%-less than 75%
C: 25%-less than 50%
D: 0-less than 25%

Figure 2 above demonstrated that all companies claimed that at least 25% of their projects per each five year period could not meet the deadline. Further we aimed to analyze the drawbacks of the project management techniques in use. 10 factors were given to the respondents to evaluate. These factors are;

A: Insufficiency for complex projects,

B: Inaccurate time estimates,

C: Inadequate planning,

D: Incapability in controlling and monitoring project over duration,

E: Insufficiency in predicting problems,

F: Resource scarcity due to inefficiencies in resource allocation,

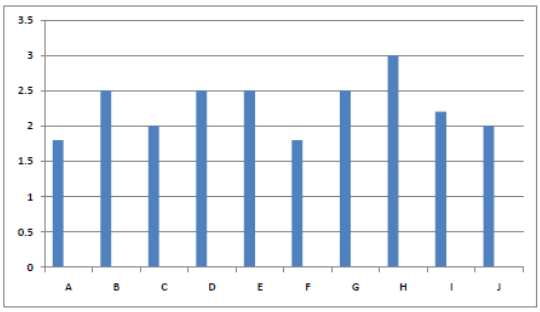
G: Difficult to conduct multi-projects,

H: Insufficient communication mechanisms,

I: Incapability of handling scope changes

J: Employee tendency of spending safety times embedded in tasks.

Figure 3. Drawbacks of project management techniques in use



Based on the fact that average value of each factor represents respondents overall tendency in considering a factor as a drawback in their project management experiences, changing values between around 1.8 and 3, indicate that all users agreed that they encounter limitation factors defined above (where 1= strongly agree and 5= strongly disagree). Insufficiency for complex projects and resource allocation problems were the factors that respondents showed a slightly higher tendency towards strongly agreeing.

Respondents were also asked about the factors that may enhance and improve performance of project management practices. For this part 9 factors were offered to the respondents; improving communication between project members through regular meetings, increasing involvement in planning, effective resource allocation mechanisms, realistic and reliable project schedule, improving concurrency through multi-project pipelining, effective monitoring and feedback mechanisms that give insight to management, better defining of roles and responsibilities of project members, integrating mechanisms for capturing complexities and interdependencies of projects, more effort can be spent on preliminary analysis for workflow planning for decreasing and anticipating complexities due to dependent activities, spending more effort on risk management activities. They strongly agreed that defining roles and responsibilities of project members may have a noticeable effect on the efficiency of project performance. Results varying between 1.5 and 2.5 exhibit the agreement of respondents to all other factors that may increase efficiency (where 1= strongly agree and 5= strongly disagree). According to the results, integrating mechanisms and tools for anticipating dependencies, better workflow planning tools and risk management activities have significant potential to improve practices.

CONCLUSIONS AND RECOMMENDATIONS

In this study complexities and uncertainties which limit the capability of project management techniques are analyzed. Analysis through case studies, literature and questionnaire findings reveal that CCPM is a more robust project management methodology compared to traditional techniques such as PERT/CPM in the case of NPD. However, it still suffers from risks originated from uncertainties which prevent it from achieving its potential. Nevertheless these project management techniques can be integrated with particular tools that are instrumental in anticipating the complexity of the product structure and eliminating uncertainties in the planning process. Decision making, risk analysis and preliminary analysis techniques can be instrumental in capturing uncertainties that affect CCPM's efficiency.

According to questionnaire conducted, most project performers agreed that spending more effort on risk management can be instrumental in increasing efficiency. Moreover, they agreed that preliminary analysis for workflow planning for decreasing and anticipating complexities due to dependent activities can be beneficial. They further agreed that effective resource allocation mechanisms, realistic and reliable schedules, effective monitoring and feedback mechanisms that give insight to management, better defining roles and responsibilities and increasing concurrency through multi-project systems are among efficiency improvement strategies in NPD projects. Although, CCPM is enough for most of them, it still has limitations that have to be addressed.

Depending on that one problem in CCPM is the application of its multi- project pipelining mechanism in complicated environments and it fails when collaboration and communication cannot be provided, Design Structure Matrix (DSM) and Domain Mapping Matrix (DMM) can be useful in this case for overcoming obstacles in CCPM. Specifically, matrix based techniques such as DSM can be used to conduct a preliminary analysis and to eliminate uncertainties originating from iterations and dependencies. They give an insight to product development managers about how to eliminate complexity in product design structure, project flow sequence and design of an organization (Danilovic and Browning, 2007). Use of these techniques aids organization according to dependencies between project domains. A supportive case study by Danilovic and Browning (2007) demonstrates its practicality. According to their analyses DSM and DMM techniques together provided a more robust multi-project structure and more carefully planned communication and coordination among multiple projects.

If workflow planning can be done better and complex design of workflow can be anticipated, the performance of project management planning and scheduling can be increased. Systematic workflow methodologies for making new product development optimal in the aspect of informational structure can be effective tools for increasing capabilities of CCPM. By the way of eliminating risks stemming from rework and unexpected tasks, a more accurate scheduling can be obtained. Implementation of such a strategic methodology which optimizes workflow by using fuzzy design structure matrix (FDSM) is investigated in a supportive case study and this method proposes an optimal activity planning for workflow. A company which applied the proposed method is OBM international electronic company operating in China obtained an efficient process. Methodology provided fuzzy evaluation and it was instrumental in determining the dependency degree of activities and bringing order to design tasks (Ma, Co and Luh, 2009:102).

One significant problem with PERT/CPM according to findings from questionnaire, literature review and case study analyses is the resource allocation problem which does not

consider resource constraints. When using these techniques frequently resource allocation is done as a separate step and it is based on the subjective perception of project managers.

Objective methodologies that give opportunities for optimization of resource allocation to prevent unexpected schedule delays can assist project managers by providing effective decision support tools. For instance, benchmarking modification mechanisms for improving new product development activities and avoiding unforeseen delays in project schedule can be utilized. These decision-making supporting techniques can be helpful to overcome problematic issues about long project durations and resource constraints. Specifically, data envelopment analysis (DEA) based benchmarking methodologies can be used to optimize product development processes and to overcome resource and schedule overruns in PERT/CPM applications. By using a systematic benchmarking approach, subjective behavior in time estimates and resource distributions can be prevented. A supportive case study exhibits successful implementation of DEA based benchmarking methodologies used in the development project of a music mobile phone. According to the methodology, after constructing a project schedule and identifying the expected project completion time by using traditional PERT/CPM techniques, analytical processes for optimizing the NPD processes are applied. (Chiang, Trappey and Chen, 2008:161).

Based on the CCPM application's requirement for change of behavior and mentality when combined with high level of complexity in some projects, employees may refuse to alter their current practices. Case studies reveal that implementation of CCPM was encountered with employee resistance and decreasing morale because of quick buffer consumption in the early stages of implementation. If procedures and meetings can be arranged systematically, and roles and responsibilities in CCPM culture can be assigned professionally, this problem can be overcome. It is a cultural change with new emerging roles for project environments. Buffer analysis and task management roles in particular should be assigned to ones that are skilled and capable of foreseeing risks and taking preventative measures against risks. Activities and meetings should be organized according to the nature of projects conducted. For instance, in the case of very complicated and ambiguous projects exposed to risks, meetings for monitoring and analysis should be done more frequently.

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