Matrix-based Project Risk Management

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In former research works matrix-based methods were developed for supporting multilevel project-planning problems. By using the introduced method traditional agile and extreme project management approaches can also be supported. Best project scenarios can be selected by genetic algorithms, and also by exact algorithms. However these methods are used for project planning, they can also be used for simulations, and can be applied for risk management purposes.

Score values can be attached to the tasks, dependencies and also to the subprojects. In this way score value of a project scenario and a possible project plan can be described by a function of the score values of task completion and/or subproject completions. In this model scope of the project can be characterized as mandatory and score values of compulsory task completions (see i.e. MoSCoW-analysis for IT-projects). *The goal of this research is to model the project success in case of different types of projects and project management approaches*. This paper is the first one in a series in matrix-based project risk management. The risks of two kinds of project management are compared.

Introduction

There are a lot of recent researches about project success (Gido & Clements, 2009) and project success factors (see i.e. Cooke-Davies, 2002; Belout, 2004). Researchers distinguish objective (like: satisfying the project scope within time/cost/resource constraints (Atkinson, 1999) and subjective (like: human factors Thomas & Fernandez, 2008) success factors of the project. In this study objective success factors that influence the project success are modeled and investigated.

According the Chaos Reports projects can be classified into 3 classes (success, failed and challenging projects) (Chaos Manifesto, 2012). One of the most interesting results of this report was that the IT projects managed by agile project management approaches was 3 times more successful than the traditional waterfall projects. In this study the novel framework of risk analysis system: REACH 4 P^3 (Risk Evaluation, Analysis & Classification for Hierarchical Process & Project Plans) is used to simulate the changes of the parameters (like: time, cost and resource demands). There are several novelties in this framework system: on the one hand this framework system can handle the completion importance of the task and the probability values of task dependencies as score values; on the other hand new task completion and new dependencies can also be indicated.

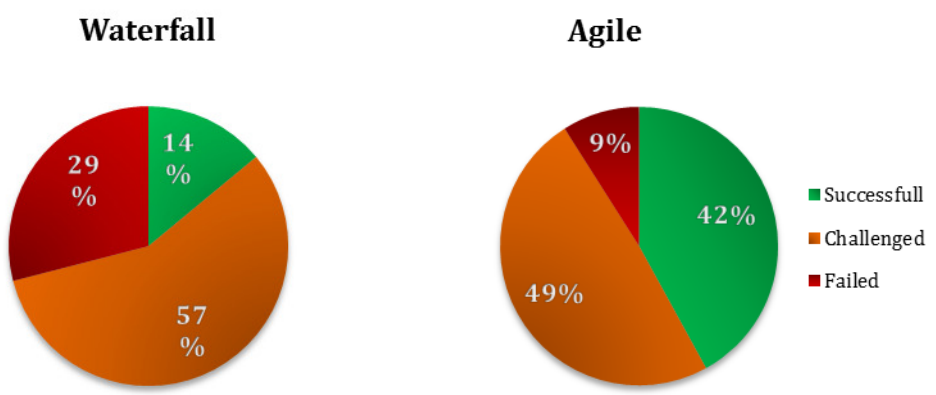
Background of the study

In this study matrix-based method is used instead of network-based project planning techniques. Two kinds of approaches are investigated: agile and traditional project management approaches, therefore these approaches and these techniques will be compared.

Agile versus traditional project management

In case of IT projects the application of agile project management approach is often three times more successful than non-agile like traditional waterfall software developing projects, according to the 2011 CHAOS report from the Standish Group (Chaos Manifesto, 2012) (see Fig. 1).

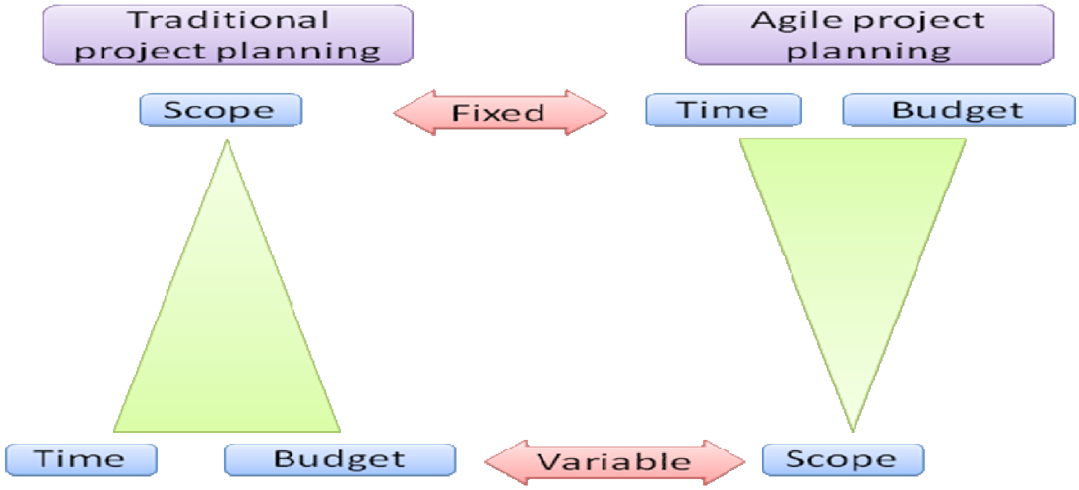
Figure 1: Success rates of agile and waterfall projects (Chaos Manifesto, 2012)



Comparing the aims and constraints of the project in agile and traditional project planning when applying agile project planning methods used in IT projects, everything is put up-side-down. While in traditional construction projects the scope of the project and list of tasks, which have to be realized are given. The objective function could be the minimal total cost, resource levelling, or minimal project duration etc. In agile project planning deadlines, resource and cost availabilities are fixed (see Fig. 2). The goal could be the realization of as many tasks as possible, whichever tasks are the most important for realization.

There are very few methods supporting agile project planning. It is hard to use traditional network planning methods, but matrix-based methods can handle the specialities of the IT projects (see Kosztyán & Kiss, 2013).

2: Comparing the traditional and agile project planning (Dalcher & Brodie, 2007)



Figure

Network-based versus matrix-based project planning

The most frequently used, traditional project planning methods (for example, network-planning (Eisner, 1962; Roy, 1962; Kelley & Walker, 1959) methods, Gantt charts (Gantt, 1974), Line of Balance methods (Al Sarraj, 1990) primarily support the operative tasks of project planning. Having an accepted logic plan, where tasks and the dependencies between tasks are determined, we can schedule tasks and allocate costs and resources by using different kinds of network planning, cost and resource allocation methods (Brucker et.al., 1999). However, these algorithms slightly support decision-making problems such as:

- Which tasks or subprojects should be selected for a new project?
- Not having a strict technological order of tasks, which is the best possible sequence of tasks regarding time, resource and cost demands of the project?

Supporting the logic planning (Kosztyán & Kiss, 2010) we use matrix-based methods instead of traditional project planning techniques, aiming to meet management claims.

Network planning methods can also be used for risk analysis and evaluation. Cost/time/resource demands of the tasks varied, but in case of matrix-based methods the importance of task completion and the probability of task dependencies can also be changed.

Methods

This matrix-based project planning method can handle if a task or a dependency is ignored or a new/an alternative task or dependency will be specified to the project plan, therefore different kinds of project scenarios and project plans can be simulated. Some of them will be failed projects, but others will be successful ones.

Score values can be attached to the task completion. This score value is equal to 1, if the task is mandatory. The task score value is positive, but lower than one, if the task is supplementary. This score value can explain the relative importance of task completion. The score value of a project scenario will be the sum of the score value of realized task completion. In this way more task completions produce higher score value of the given project scenario. The *logic plan of a project scenario is feasible*, if every mandatory task decided to be realized and the score value of a project scenario is not lower than a constraint. A project scenario is feasible, if the logic plan of the project scenario is feasible, and the time/cost/resource demands of the project are not greater than the constraints. The scope of the project is characterized as minimal requirement of a project. Minimal requirement always contains mandatory task completions and rarely any important task completions which are described as their score values.

Groups of project scenarios

Similarly to the CHAOS reports 3 kinds of projects can be distinguished.

1. *A project is successful*; if every project scope is satisfied, within the time/cost/resource constraints. In other word the given project (scenario) is feasible.
2. *A project is a challenged project*; if every project scope is satisfied (the logic plan of the project scenario is feasible). Although this project (scenario) is not feasible, because time, cost or resource demands are higher than a constraint, these demands are within a tolerance.
3. *A project is failed* otherwise.

Parameters changing

Different kinds and different types of real IT project plans are considered and various kinds of parameters will be changed (like: time/cost/resource demands, ratio of task completion, probability values of dependencies etc.) In this model time-, cost and resource demands, task completions realization of a dependency, new task occurrences can be characterized as probability values. These probability values can follow different kinds of distributions. In this way score values of projects can be calculated for different kinds of projects. This model can also be used to simulate shock effects. It means that not every, but a given ratio of task parameters are changed drastically. It is assumed that a higher score value of task completion and task dependency proceed higher probability value of desired realizations. For example, if the score value of task completion is 1 it means that it is a mandatory function, therefore the probability of desired realization will be 1. Although shock effect can change not only time/cost and resource demands, but also the probability values of desired realizations. The final probability values of the realization of task completion or task dependencies will be calculated after simulating shock effects. Therefore we can simulate that the mandatory tasks will not be realized.

Agents for approaches of agile and traditional project managements

Agents are computer programs, based on scheduling, cost minimizing and resource allocation algorithms. The aim of these programs is to specify a feasible project scenario from a stochastic project plan. The *Traditional Project Management agent* (TPMa) can use traditional time/cost trade-off methods in order to reduce time and/or cost demands (see i.e. Prabuddha et al., 1995; Feng et al., 2000) of the project, and can use resource allocation and/or resource leveling algorithms for specifying a time and/or resource constraint resource allocation (see i.e. Brucker, 1999; Kosztyán, Perjés & Bencsik, 2008), but the logic plan of project is fixed, the project plan will not be restructured. The *Agile Project Management agent* (APMa) can ignore supplementary task completions, and can restructure project if uncertain task dependency is ignored. In this way the logic plan can be restructured considering the management claims (see i.e. Kosztyán & Kiss, 2010, 2013; Kosztyán, 2012).

Simulation and empirical results

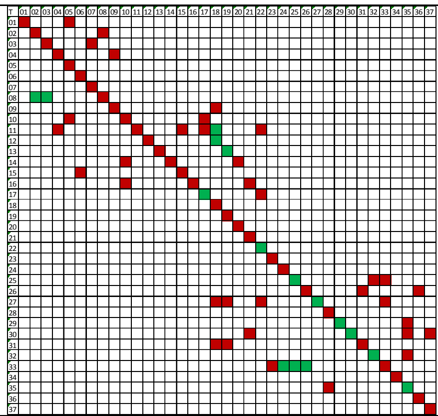
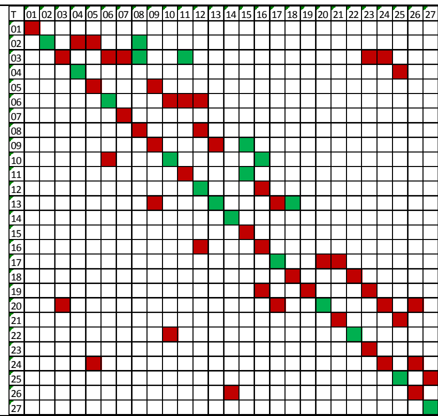
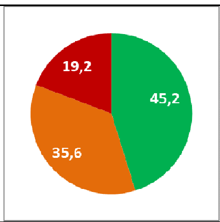
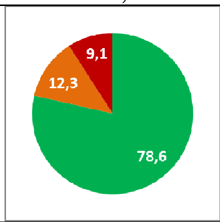
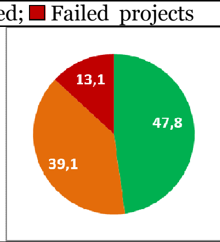
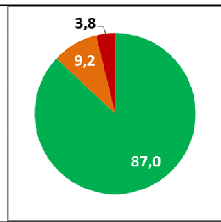
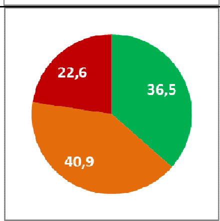
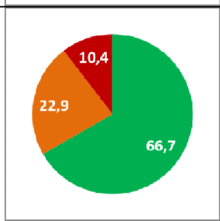
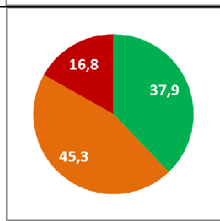
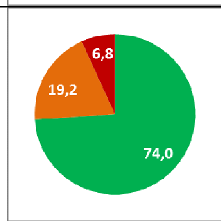
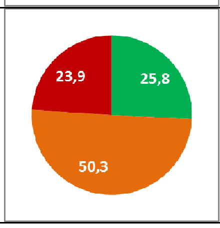
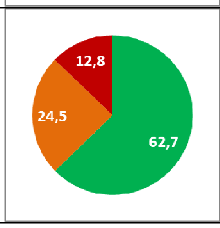
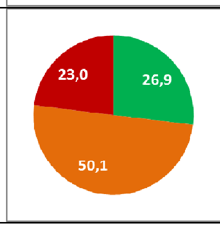
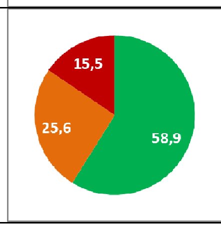
In this simulation 2 different real software development projects are considered. Based on interviews the score values of task completion are specified. In these projects the ratios of mandatory and supplementary functions are different. The original project plans have been revised by corporate experiments: considering a task dependency between tasks, if there is no technological proceeding, but the original project plan consists dependency between these two tasks the dependency specified as uncertain dependency. It means: we can complete these tasks in a sequence according to the original project plan, but if there are enough resources and the technology can allow the task completions can be parallelized and the uncertain task dependency can be ignored. Table 1 shows the percentage of uncertain task completions and task dependencies according to the revised project plans. These projects contain time, cost and 3 kinds of (manager, programmer, tester) resource demands.

At the simulation stage 1: after specifying revised project plans, considering the former project experiments the expected values of time/cost resource demands based on the original project plans, but in the pessimistic project plans tasks need 30% more time, 20% more cost and 50% more resource demands. While in the optimistic project plans tasks need 10% less time, 5% less cost and 10% less resource demands. It is assumed, that the time, cost and resource demands follow the ☐ distribution. By using the Monte Carlo simulation the uncertainty of project parameters can be simulated (uncertainty effect).

The next step is to apply the modified or two-step Monte Carlo simulation. In this case the extreme or shock effects (like system failures) can also be simulated. In this case the first step is to select tasks, where the parameters would be changed. In this simulation the selection ratio is 5%. The second step is to change the parameters for the selected tasks. The difference between the one-step and two-step Monte Carlo simulation is that in the first case every task's parameters can be changed, but in the second step only selected task parameters have been changed. At the same time the shock effect is higher for the selected task than the uncertainty effects. We assumed that the shock effects are between 50% and 100%.

At the same time in case of software development projects the scope can also be changed during the project realization, therefore the score values of task completion can also be changed. At the simulation stage 2, the score value of task completion and dependencies can be changed. If a task completion is changed from 0 to greater than 0 it means a new task completion will be specified. In this case the dependencies, cost/resource/time demands are also generated for these new tasks. If a task completion is changed to 1 it means that this task completion has become a mandatory function. For simulating the changes of the specification of the project the two-step Monte Carlo simulation is applied again. Considering the proposals of the corporate experts 20% of score values of the task completion can be increased maximum 50% and 10% of new task completion can be generated. Parallel to the simulation stage 2, agents of TPMa and APMa (see previous chapter) are used to manage project plans in order to satisfy the constraints and management claims. Time, cost and resource constraints are 80% of maximal values of time, cost and resource demands. The minimal requirement is to complete all mandatory functions and reach 80% score value of the sum of all score values of task completions. The TPMa uses time/cost and time/resource trade-off methods in order to decrease time demands. In this case the crash cost and resource demands will increase 20%, when time demands can decrease 10%. After 10 000 simulations the result of success of projects is shown in Table 1.

Table 1: Simulation results

Matrix-based project planning =Mandatory =Compulsory task completions/ task dependencies					
Stages/Agents		TPMa	APMa	TPMa	APMa
		Success; Challenged; Failed projects			
Stage 1	Uncertainty effect				
	Shock effect				
Stage 2	Changing scores				

Summary, conclusion and future works

Despite the fact that the agent of APM cannot produce 3 times more successful projects, the number of success project scenario is significantly higher than in case of using traditional project management techniques. In future research an adequate combination of traditional and agile project management techniques should be investigated.

With REACH framework algorithm model time-, cost and resource demands, task completions realization of a dependency, new task occurrences can be characterized as score values and these score values can also be changed by simulation technique. As a result probability of success projects can be calculated for different kinds of projects and later multi-projects. This study does not consider multi-projects however REACH framework method can also be used with hierarchically organized multilevel projects. This model can be used both to simulate shock and uncertainty effects.

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