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Towards a Theory of Project Management Using Conceptual Modeling

Michael Thygs and Christian Brelage

European Research Center for Infor. Systems (ERCIS), Leonardo-Campus 3, 48149 Muenster, Germany, {thygs, brelage@ercis.de}

ABSTRACT

Despite considerable research on project management, the success rate of projects is still unacceptably low. At an average of 68% information system (IS) development projects were not completed successfully, although there are many methods and techniques dealing with the modeling and execution of information system development projects. The phenomenon of failed projects is caused at least partially by communication problems within project teams and misunderstandings of current project management methods. We argue that researchers lack a common PM-specific language that can be used to exchange ideas. By using a design science approach, we create a PM-specific language by means of a conceptual model that can serve as a theory for practitioners and researchers alike. Moreover, we are assessing the agile method SCRUM by applying the model, in order to show is utility and applicability.

INTRODUCTION AND RELATED WORK

The use of projects as a form of organization is known since the early 1960s. However, the management of tasks, which are now called projects, is much older. The emergence of project management is the result from the increasing number of projects and their diversity and intricacy (Barnes 2002). Nowadays projects can be found in many organizations (e.g. in research and development department, IT department, call center) and more and more organizations base on projects (consulting, software development, and service companies). The project management profession is becoming more important in corporations, governments, academia, and other organizations worldwide (Kloppenborg & Opfer 2002).

Despite research efforts on project management, the rate of successfully finished projects remains low (The Standish Group 1998). *The Standish Group* examined the data of 23.000 application projects and reveals that in 1998 the success rate of IT projects in small companies is as low as 32% and in large companies is as low as 24%. The average project costs in large companies fell from $ 2.3 Million to $ 1.3 Million, whereas the costs in small companies rose from $ 0.4 Million to $ 0.6 Million. Compared to the figures in 1984 the development shows a significant improvement. However, the success rate is still low, especially when the growing use of project management is taken into account (Barnes 2002). More details concerning project escalation and failed projects can be found in (Keil 1995, Keil & Mann & Rai 2000, Schmidt, et al. 2001).

Kloppenborg & Opfer examined 3.554 articles, papers, dissertations, and government research reports in a study of the current state of project management research in order to identify the state-of-the-art of project management research (Kloppenborg & Opfer 2002). They used the nine knowledge areas described in the PMBOK® Guide (A Guide to the Project Management Body of Knowledge) (Project Management Institute 2000) and identified, that 64% of the documents written in English deal with the typical triangle of cost, time and quality. Only 5% of the papers deal with integration and, more notably, only 8% with communication issues. Despite the numerous publications, an explicit theory of project management seems to be missing. *Kloppenborg & Opfer* state that the theory of project management research should be evaluated in more detail. *Koskela & Howell* argue that there is an implicit and narrow theory in the project management at the present time, which has to be developed, extended and enriched (Koskela & Howell 2002b). They differentiate between the *theory of project* and the *theory of management* and identified missing aspects in both categories of the current project management theory. They claim that a paradigmatic transformation of the discipline of project management is needed. But the problem remains unsolved. They see a potential improvement through concurrent development of theory and practice.

Our research on project management enhances the so-called Body of Knowledge, which provides the project manager with knowledge (information needs) needed to perform the project(s) (Morris 2000, Project Management Institute 2000). The interchange of knowledge relies on generating, processing, and transforming information. A cornerstone in project management field is the management of information. We address the *theory of projects* in our research. Thus we can formulate our research question: Which concepts of project management constitute a theory of projects and how can these concepts be used in PM research theory and practice? We answer this question by developing a conceptual model of PM using the language critic approach of design science. This model provides sound means for analyses in the context of PM. We demonstrate the applicability of the model by assessing the PM method SCRUM.

Accordingly, the structure of the paper is as follows. Section 2 elaborates the research approach and its background. Section 3 contains the description of our conceptual model. Section 4 illustrates the applicability of the model to the PM method SCRUM. Section 5 concludes the paper.

RESEARCH APPROACH AND BACKGROUND

A scientific theory provides means for the understanding of a given domain or area of research. It represents the body of knowledge in that domain and serves as a general framework for practitioners and researchers alike. Thus, a theory can be regarded as a (language) standard for the discussion and verification of ideas and assumptions about a given domain.

Although there are numerous publications proclaiming standards and theories about project management (Burghardt 1997, Fowler 2003, Haberfellner 1997, Jenny 1995, Kerzner 1996, Koskela & Howell 2002a, Madauss 1990, Paulk 2002, Project Management Institute 2000), the empirical investigation indicates the need for further research on project management and its foundations (Kloppenborg & Opfer 2002). It is an obvious fact that project failures are (at least partially) caused by communication deficits and misunderstandings caused by the lack of a common language (respectively standard) of project management and its concepts (PM specific terms like task, project, etc.). Moreover, a lot of material about PM is published or invented in order to create consulting needs. It is hard to assess the applicability of a certain method for a given problem or project as long as the usage of definitions and terms varies greatly and “new buzzwords” are constantly created. Thus, the need for a PM theory becomes evident.

From a scientific point of view, we are following the design science paradigm (Hevner, et al. 2004). Design science seeks to create new and innovative artifacts (Hevner, et al. 2004). An artifact can be a construct (a vocabulary like in our case), a model (a representation of something), methods (algorithms or practices) or instantiations (prototypes). The relevance of our research is justified by the extensive empirical evidence given by Kloppenborg and Opfer (Kloppenborg & Opfer 2002). The main contribution of our work is the PM specific language that is constructed rigorously by using the language critic approach (Kamlah & Lorenzen 1984).

As *Kamlah and Lorenzen* stated, a common language is needed in order to speak about things and objects of the real or imaginary world in a scientific, meaningful and efficient manner. A native language is given to all individuals (e.g. English, German, etc.). Unfortunately, it is barely scientific and imprecise. A scientific language has to be constructed by incrementally defining core concepts precisely and non self-reflective. We are using this approach by our step-by-step reconstruction of concepts and terms of PM in section 3.

We are using the language critic approach in order to create a conceptual model that represents our PM theory. The purposes of conceptual modeling are (1) supporting communication between developers (project members) and users (stakeholder), (2) helping analysts understand a domain, (3) providing input for the design process, and (4) documenting the original requirements for future reference (Kung & Sølvberg 1986). A model is defined as an abstract picture of an object of the real or imaginary world with respect to a subject (Becker & Schütte 2004). The term conceptual implies a high level of abstraction.

In order to communicate the findings of our research more precisely and formally, we use entity-relationship modeling in addition to the descriptions of concepts in plain English. The Entity Relationship (ER) modeling language invented by *Chen* (Chen 1976) supports the following basic linguistic actions (compare Table 1). ER modeling is widely used, well understood and is regarded as the lingua franca for IS research (Rosemann & Green 2002). For details on ER modeling refer to (Becker & Schütte 2004, Chen 1976, Rosemann & Green 2002, Scheer 2000).

CONCEPTUAL MODEL OF PROJECTS

We base the reconstruction of our PM specific language on the PMBOK® (Project Management Institute 2000), German Institute for Standardization (DIN) (Burghardt 1997, DIN69901 1989, DIN69902 1987, DIN69903 1987, Fowler 2003, Jenny 1995, Kerzner 1996, Madauss 1990), and practical experience in order to identify the fundamental terms of PM theory. These terms and their relations build the vocabulary of PM and represent the objects and things that have to be managed and monitored in order to successfully conduct projects. From an IS point of view, information that is exchanged within a project always refers to at least one of these terms. Due to length restrictions, only some core concepts are described in detail.

The model, which is modeled using the Entity-Relationship-Method (ERM) (Chen 1976) including min-max-cardinalities (Becker & Schütte 2004), is described step-by-step in this section. According to the research methodology described in chapter 2, the conceptual model is the starting point of the ontological examination of the project terms. The conceptual model consists of the fundamental terms and their relations. Each fundamental term is associated with a clear meaning.

The fundamental and crucial term (concept) in literature and practice is *task*. The definition, planning, execution and control of tasks are the source of every activity in project management methodologies. Even the human centric methodologies, like the agile methods, use tasks as a core concept. A task is an objective for purposive human action (Kosiol 1976). Tasks are aggregated to extensive task (*task structure*). The *project* at its whole is the most extensive task. Projects are characterized by the assignment of budget, contract, group of resources, the usage of a specific project life cycle, and a well defined deliverable (DIN69901 1989, Jenny 1995, Litke 1991, Madauss 1990). *Activities* are the smallest units handled within project management methods. Tasks are structured by using different levels of abstraction and different types of relationships (e.g. technical and logical constraints or management guidelines). This conceptualization of tasks, projects, and activities encompasses concepts like work package, scope, and sub-project that are mentioned in the literature. However, these concepts do not have special characteristics that require an explicit conceptualization, since they can be constructed by using the task structure.

The usage of *phase* (procedure) models is a common approach in order to reduce the complexity. A phase is a factual and logical restricted period of time that is defined by the project management method. The assignment of tasks to phases is carried out by project team members respectively by the project manager. However, the assignment is restricted due to logical constraints (e.g. implementation prior to testing). Every phase has one or more *deliverables*. The deliverables are the material or immaterial, tangible, and verifiable products like a feasibility study, a detailed design, or a working prototype (Project Management Institute 2000).

A *risk* is a possible negative deviation from the project objective(s) (Kerzner 1996). Each project is subjected to at least one risk but not to all risk that are identified. The risks that threaten the projects success are related to the project objectives.

Stakeholders are individuals or organizations, who are involved in the project or in some tasks. The stakeholders influence the result or are the users of the system. In contrast to the PMBOK® we differentiate the project team members (*resources*) from the *client* and *information retrieval* stakeholders. The project team members are directly involved and therefore cause costs, use budget, are integrated in the project organization and are responsible for the execution of tasks. Therefore, project members and stakeholder have to be differentiated, although there is accordance in information supply and their influence on the project objectives. The project team members are *persons*, which are part of the project resources. Resources represent anything needed to perform tasks. The most important resources are persons (staff), who execute tasks. Apart from staff, technical resources like computers, machines, software and tools are used to perform the project, which we subsume by using the term *equipment*. The resources itself have to be classified by *properties*, which are useful for the project. In case of persons properties are *skills*. Other resources have functions, which are needed during the project. Skills and functions have to be measured and rated with *quality* measures.

In contrast to the PMBOK®, the assignment of quality to tasks seems to be sensible for a detailed quality management. However, it may be difficult to obtain meaningful quality measures at the end of each task. Thus, the measurement of the quality that is actually achieved has to be measured at the end of each phase.

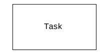
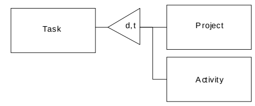
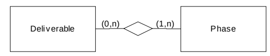
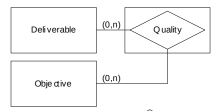
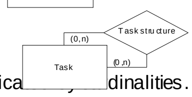
Time, costs and *quality* represent fundamental concepts, which have to be managed in projects. These concepts are usually visualized by a triangle. Time and costs are directly allocated to the tasks and can be measured easily. The expected and adequate quality depends on the deliverable and its objectives (and the customer need or guideline). Thus, quality is always related to a deliverable and an objective. The degree of quality that is actually achieved depends on efficient allocation of resources and efficient task management.

This is illustrated in Figure 1 by the two different paths form deliverable to quality (firstly, directly by referring to objectives and client (= expected quality) and secondly, the quality of the resource property in combination to the allocation of the resource to the task and the tasks to the phase, in which the deliverable is produced (= delivered quality). As stated above, the concepts of our PM specific language are depicted by using the following ERM model.

EXEMPLARY APPLIANCE OF THE THEORY TO THE AGILE PROJECT MANAGEMENT METHOD SCRUM

Many methods in project management use plans and planning systems (Project Management Institute 2000) in order to structure the project. However, more modern methods (especially agile methods (www.agilealliance.com) (Fowler 2003) like SCRUM (Schwaber & Beedle 2002) and eXtreme Programming (XP)), use other concepts in order to

Table 1. Linguistic Actions Supported by the ERM Language

Linguistic Action	Description	Example
Subsumption	Subsumption classifies one or more objects that are considered to be equal in the given context (typecasting of objects). Depicted by the entity symbol (rectangle).	
Subordination (generalization or specialization)	Subordination characterizes entities that are related by generalization/specialization relationship like those known from object orientation (a mammal is a special animal, animal is the general term). Symbol: Triangle.	
Composition (Aggregation)	Composition allows the creation of new entities (objects) by combining existing ones. Symbol: Rhombus.	
Composition (Re-Interpretation)	Re-Interpretation of relationships allows the aggregation of entities and the reuse of the resulting construct as a new entity. Symbol: Rectangle-Rhombus	
Recursion (hierarchies and structures)	Recursions are used to depict hierarchies or structures (depending on the cardinalities) of objects. Symbol: Self-reflective relationship (rhombus).	
Dependency	An entity is dependent on another one. Depicted by min-max-cardinalities. A minimum cardinality of 1 indicates existential relationship.	Indica[illegible]dinalities.
Attributes	Objects resp. entities may be adjudged with attributes that characterize all instances of that object (Attributes of entities depicted by ovals in ERM notation).	Not used in this case.

structure the work. In order to demonstrate the applicability of our theory, we are using the model from section 3 for the assessment of SCRUM. We describe SCRUM briefly and match the concept and terms that are used by SCRUM against our theory. Figure 2 shows the result of the matching. The shaded constructs are not part of SCRUM; the highlighted constructs represent main constructs. All other constructs are implicitly contained in SCRUM.

The main construct of SCRUM are sprints, which are represented by phases in the theory. The phase structure is less important, because the team delivers a fully operational software product and improves this product from phase to phase. The product owner (client), the scrum master (resource) and the team (resource) discuss the quality of the functions (deliverables) and define the work (tasks) for the next sprint (phase) in the sprint meetings. Moreover, the deliverables for the next phase are specified during the sprint meeting. In general, tasks are not explicitly specified in SCRUM. The project is managed by the definition of deliverables instead of task. The holistic, integrated vision of the project is specified in the global backlog (deliverables). As in any agile method, the communication between the customer and the team is very important. Thus, information retrieval is a main construct of the method.

The shaded constructs like costs, budget, risk, availability of resources, and task structure are not mentioned in the methodology. Obviously, SCRUM does not provide any means concerning budget management or cost management. Whether this fact is an obstacle for the appliance of SCRUM depends on the specific project and its characteristics. The project manager has to decide whether the project can be carried out without a budget management or which alternative should be used. Nevertheless, it is very important for project managers and team members to be aware of these implicit premises of PM methods.

Following the SCRUM method, plans are not essential for projects (in contrast to traditional PM approaches), but the task structure has to be arranged somehow (Figure 1: Task structure). By using the type of relationship the criteria of the task sequence as the work breakdown structure in classical projects or the sprints in SCRUM can be specified.

CONCLUSION AND FURTHER WORK

The high number of publications in the project management discipline indicates the importance of project management as well as its immaturity. The low success rate of projects implies serious financial risks as well as missed schedules and inadequate quality, posing serious threats for organizations that are based on projects.

We argued that project failures are at least partially caused by communication deficits and understanding problems. The vast numbers of publications prevent a sound assessment of methods, tools and techniques in project management. Moreover, the discipline is characterized by a huge number of methods that provide solutions for parts of the overall problem. However, integrative approaches are needed in order to reflect the complexity of the project holistically.

We provided a conceptual model that can be used as a starting for further research on project management theory. By using the language critic approach we analyzed current project management literature and reconstructed core concepts systematically. The resulting model provides a sound basis for theory of project and serves as a common language practitioners and researchers alike. We demonstrate the applicability of the model by analyzing the agile method SCRUM. The analysis reveals that SCRUM has no concepts for budget and cost management.

Currently, the model concentrates on the theory of projects. Further research is needed to cover the management aspects. Additionally further research can concentrate on the evaluation of other project management methods as well as the extension and refinement of the model. Moreover, the model can be used for the assessment of the project management capabilities of software engineering methods like UML 2.0, ARIS and CASE tools. Furthermore, the model can be used to develop a new method for project management. Moreover, it can be used to identify methods that can be used simultaneously to cover project management holistically (like SCRUM and budget management).

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Figure 1. Model of Project Terms

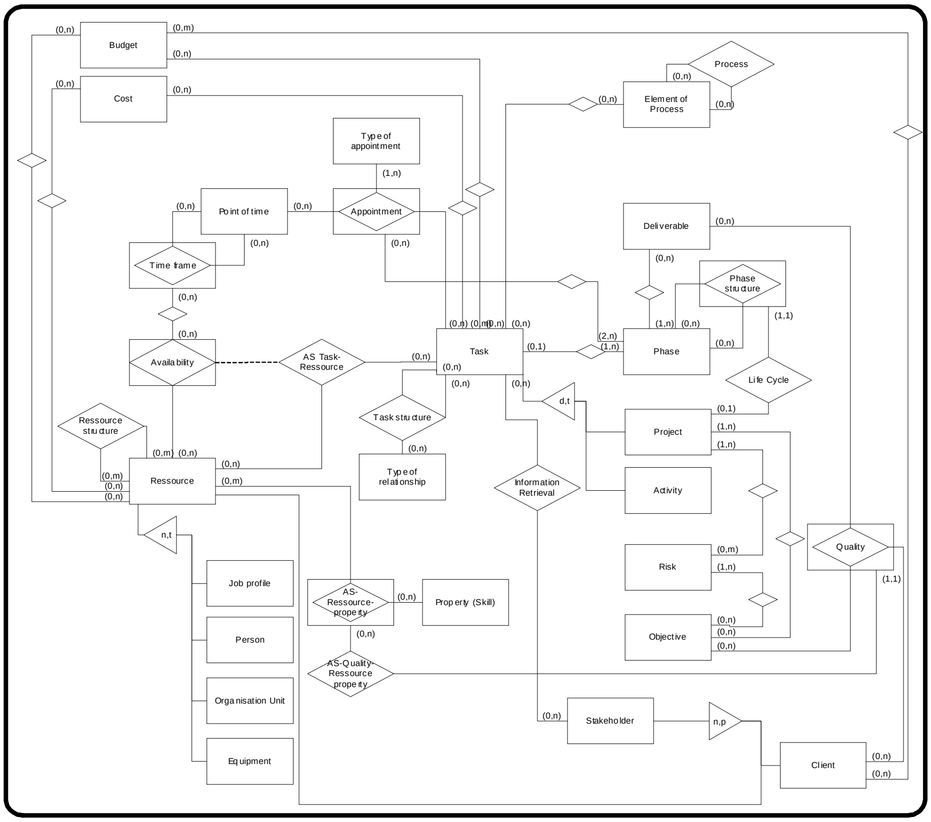
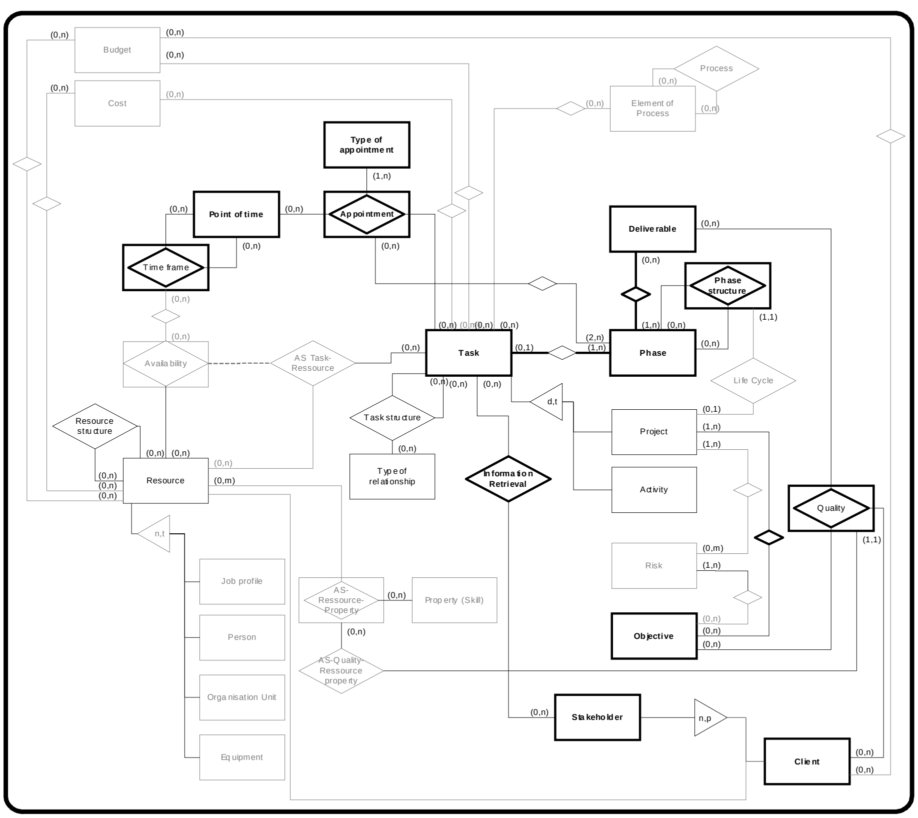


Figure 2. Analysis of SCRUM Using the Conceptual Model



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