A Formalization of Software Product Line for Project Management

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Abstract. Software product line(SPL) is one of the best development method for software reuse. SPL have known as an increasing used method over the last years, that has taking advantage from the important benefits of software development in terms of time, cost and effort.

Even though SPL is extremely effective for reusability, management of the SPL is a bit complicated. In other words, utilization of existing Project Management(PM) might be insufficient for SPL. Therefore, due to this complexity, the most suitable way is utilization of the Formal model(FM). The formalization of SPL might be more efficient in project management process. This paper proposes a MOM net based formal model of SPL for software Project Management and control. Using this model, project process can be accomplished clarity and efficiency for PM.

Keywords: Software product line, Software engineering, Project management, MAM net model, Formal model.

1 Introduction

A project is temporary in that it has a pre-defined beginning and ending, and also has a restricted scope and resources. PM is a methodical approach to planning and guiding project processes from start to finish [1]. Also it is essential for managing complex projects in organizations, especially in large-scale organizations. PM is nowadays a key activity area, as developments and changes, both in smaller and in large organizations, that can be efficiently implemented in the form of projects [3].

SPL is one of the most critical way for software reuse and software project management. In SPL, software artifacts such as requirements specification, system architecture, design, components, etc. are reused across the family of a product line with/without some adaptations [4]. In new product producing, reusable requirements, components, architecture, test case etc. are reused with some adaptation which called core asset. Therefore, reusing method will be more effective than other conventional development methods [5]. Therefore, many organizations have trying to adopt Software Product Line Engineering (SPLE) for improving the quality and productivity of information systems and software product [6].
Figure 1 shows SPLE process. SPLE consists of two main compositions. In domain engineering process, a reusable core assets are built. The core assets are software artifacts that are reused in the production of customized products in a SPL. In the application engineering process, new products are produced using the reusable core assets. There are problems in the SPLE. Firstly, there are many versions of core assets and for each core asset, there are several corresponding applications are existing. Secondly for each project can be delayed due to unplanned work during the project. Certain number of defects will inevitably remain in released software products as software testing cannot demonstrate the absence of defects [8].

Thus for the project management for this complicated SPLE, a formal model of the PM is inevitably required. For this formal model, this research survey several PM processes, SPL models and formal models and then figure out a formal model describes SPL project management.

![Software Product Line Engineering](image)

**Fig. 1. Software Product Line Engineering**

## 2 Used Tools and Techniques

A Formal Method is a collection of mathematically based techniques used in development of computer systems. [9] It clearly describes the complex system and coordinates the connection between customers and developers. Also it provides means of guaranteeing various properties of a software system that increases its trustworthiness. [10] A formal specification is simply a description of system using a
mathematical notation. Using mathematics is precise than other natural languages. Using a formal specification language, a system can be described precisely with regards to functionality, concurrency, completeness, correctness, etc. [9] In this paper we used the MAM net formal model for model construction. The MAM net is a formal model that clearly describes the processes step by step and includes the resource management such as human resource.

The objective of this paper is to create trustworthy formal model that provides understandabilities and clarities for project's roles such as customer and developer and in order to manage the project effectively using SPL method. The FORM architecture model is presented in this paper. [11] This model utilizes PMBOK Time management processes. [12]

Our hope is that this will be helpful to overcome the complexity of existing SPL development methods and to facilitate the project management process by introducing the Formal model in the point of PM’s aspects.

Fig. 2. Project Time Management Process

3 A Formal Model of Software Product Line for Project Management

The model is designed based on the PMBOK time management processes. In PMBOK, as a part of the planning process, the project manager develops a schedule management plan. The schedule management plan specifies how the schedule will be developed and managed. Also it includes the scheduling methodology, scheduling
tool for developing and controlling the schedule. Using MAM net for each step for creating the model, we also refer the different types of tools and methodologies in some step for the clearer understanding. The project schedule management with PMBOK consists of six main processes as shown in Figure 2.

The activities of MAM net expression are shown as Figure 3. For a process step, the model is denoted by \( M \Rightarrow \{\langle \text{Activity name}, R, \text{IP}, \text{OP}, P \rangle\} \). where Activity = \{activity name\}, R = \{r_1, r_2, ..., r_n\} which denotes the type of resources, IP = \{input artifacts\}, OP = \{output artifacts\} and P = \{q_1, q_2, ..., q_n\} which denotes a set of process steps identifiers. The type of resource-requests to AgentAllocationUnit represented by R = \{\text{Integer, Integer, Integer, Integer, Integer}\}. Human agents are represented by A = \{\text{Domain PM, Product PM, Customer, Developer, Tester}\}.

All of the activities are sequenced, denoted by \( P \in \{q_1, q_2, ..., q_n\} \) identifier. To arrange inputs and outputs of each activity, it should be represented as needed. The input/output artifacts of model are represented by IP = \{input artifacts\}, OP = \{output artifacts\}.

MAM net model represented as follows by activity name, input artifacts, output artifacts and identifier of activity.

\[
M = \{ \langle \text{User requirement analysis}, R, \{u_r\}, \{p_r\}, q_1\rangle, \\
\langle \text{Product planning}, R, \{p_r, b_p\}, \{p_p\}, q_2\rangle, \\
\langle \text{Feature model selection}, R, \{u_p, p_p, f_m\}, \{d_p, s_f_m\}, q_3\rangle, \\
\langle \text{Update Plan}, R, \{d_p\}, \{u_p\}, q_4\rangle, \\
\langle \text{Architecture selection & adaptation}, R, \{s_f_m\}, \{p_a\}, q_5\rangle, \\
\langle \text{Component adaptation & coding}, R, \{p_a\}, \{p_c\}, q_6\rangle, \\
\langle \text{Testing}, R, \{p_c\}, \{p\}, q_7\rangle, \\
\langle \text{Product release}, R, \{p\}, \{r_p\}, q_8\rangle \}. \
\]

If there are several artifacts in activity with similar type, comma separated list is used. It means that if there are two input artifacts in a process, we can express such as \( \{p_r, b_p\} \). The output artifact of process step is going to become input artifact of successor process step. They are connected by the arcs and dotted arcs. If an output of process step connected to a Boolean decision which means true or false, a dotted arc is used.

Artifacts can be obtained from Domain Engineering and Product Engineering process results. The artifacts that is created from the Domain engineering is \( u_r \) which means user requirements, \( f_m \) which means feature model and \( b_p \) which means base plan. The artifacts created in Application engineering are \( p_r \) which means product requirements, \( p_p \) which means product plan, \( u_p \) which means updated product plan, \( s_f_m \) which means selected feature model, \( d_p \) which means defected plan, \( u_p \) which means updated product plan, \( p_a \) which means product architecture, \( p_c \) which means product code, \( d_p \) which means defected product, \( u_p \) which means updated product code, \( p \) which means product and \( r_p \) which means released product.
4 Conclusion

The existing Project Management method is not sufficient for the SPL development method. In order to solve this problem, Formal Model of SPL development is proposed. The suggested model uses FORM method for metadata of project management information. MAM net model is used to express sequence of the model. This formal model will be very helpful to describe the complex SPL project management information clearly. This will be a novel basis for the effective process schedule management later.

For the continuous changes of the project management, the expression of the schedule management is one of the mandatory properties. The future works will include time model and its related methods. Since all the domain engineering requirements of the application engineering cannot be identified in the planning phase, the project management system should afford to accept unplanned works. Thus this kind of information should be represented in the formal way.
References