العنوان:	Management framework of softweare product line engineering real options perspective
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THESIS ABSTRACT

Full Name : ***Khalid Mohammed Hussein Al-Kahsah***

Thesis Title : ***Management Framework of Software Product Line Engineering: Real Options Perspective***

Major Field : ***Computer Science***

Date of Degree : ***May 2012***

Software Product Line Engineering (SPLE) is an approach with an aim to move the software industry away from developing each system from scratch. The fundamental idea in SPLE is building systems from the common features rather than building new systems, because systems in a certain software domain have more commonalities than uniqueness. SPLE helps to identify common features among similar family of products into core assets and then reuse these core assets to develop subsequent applications. SPL development needs a collaborative process whereby organizations can balance the conflicting interests between high reusability demand and lower cost. This process needs to focus on how to achieve the required reusability level; and handle the uncertainties during the product line core asset development. Despite the large number of research and studies that touched SPL, there is a gap in the study of uncertainty associated with features selection in the core asset development. The main objective of this thesis is to address this issue by handling that uncertainty using the Real option Theory (ROT) concepts, which offers a systematic approach to identify and assess the issues that have an effect on the real options value, and help managers to make a decision under uncertainty. In this thesis we develop Software Product Line Engineering Management Framework (K-SPLEMF) for core asset development. Our framework identifies a method to classify an SPL features into features sets based on their dependencies relations; introduces a new matrix to calculate features and Features Sets Reuse Opportunities; prioritizes features and features sets in the SPL core asset development process by using ROT concepts. Furthermore, we analyze and discuss the results of the framework application on the SPL core asset development through case studies.

ملخص الرسالة

الإسم الكامل : **خالد محمد حسين الكحسه**

عنوان الرسالة : **إطار عمل إدارة هندسة خط إنتاج البرامجيات: منظور الخيارات الحقيقية**

التخصص : **علوم حاسب**

تاريخ الدرجة العلمية: **مايو 2012**

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هندسة إنتاج خطوط البرامجيات تساعد على تعريف السمات المشتركة بين مجموعة متماثلة من المنتجات كأصول أساسية (Core Assets) و التي يمكن أعادة استخدامها لتطوير و انتاج تطبيقات لاحقة. إن تطوير خط انتاج البرامجيات (SPL) يتطلب عملية تعاونية بحيث يمكن للمؤسسات تحقيق توازن بين تضارب المصالح لمطالب اعادة استخدام مرتفعة و تكلفة اقل. هذه العملية تحتاج للتركيز على كيفية تحقيق المستوى المطلوب من إعادة الاستخدام، و التعامل مع عدم التيقن (Uncertainty) خلال تطوير الاصول الاساسية لخط الانتاج. بالرغم من ان كثير من البحوث و الدراسات تناولت خطوط انتاج البرامجيات لايزال هناك فجوة في الدراسات التي تعالج مشكلة عدم التيقن المرتبطة بإختيار السمات عند تطوير الاصول الاساسية. الهدف الرئيسي لهذه الدراسة هو تناول هذه المسألة لمعالجة مشكلة عدم التيقن عند اختيار السمات لخط انتاج البرامجيات بإستخدام مفاهيم نظرية الخيارات الحقيقية (Real Options Theory (ROT)) و التي تقدم نهجا نظاميا لتحديد و تقييم المسائل التي يكون لها تاثير على القيمة الحقيقية للخيارات و مساعدة المسئولين على اتخاذ القرارات في حالات عدم التيقن.

في هذه الدراسة قمنا ببناء اطار عمل ادارة هندسة خط انتاج البرامجيات (Software Product Line Engineering Management Framework (K-SPLEMF)) لتطوير الاصول الاساسية. اطار العمل المقدم في هذه الدراسة يعرف طريقة لتقسيم سمات خط انتاج البرامجيات الي مجموعات سمات (Features Sets) بناء على علاقات الاعتمادية بينها؛ و يقدم مصفوفة جديدة لحساب فرص اعادة الاستخدام (Reuse Opportunities) للسمات او مجموعات السمات في خط انتاج البرامجيات؛ ايضا يعرف اولويات السمات او مجموعات السمات عند تطوير الاصول الأساسية لخط انتاج البرامجيات باستخدام مفاهيم نظرية الخيارات الحقيقية. علاوة على ذلك قمنا بتحليل و مناقشة نتائج تطبيق اطار العمل المقدم في هذه الرسالة على عملية تطوير الاصول الاساسية لخط انتاج البرامجيات من خلال حالات دراسية.

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Management Framework of Software Product Line Engineering: Real Options Perspective

BY

Khalid Mohammed Hussein Al-Kahsah

A Thesis Presented to the

DEANSHIP OF GRADUATE STUDIES

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

DHAHRAN, SAUDI ARABIA

In Partial Fulfillment of the

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MASTER OF SCIENCE

In

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KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

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This thesis, written by **Khalid Mohammed Hussein Al-Kahsah** under the direction of his thesis advisor and approved by his thesis committee, has been presented to and accepted by the Dean of Graduate Studies, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **COMPUTER SCIENCE**.

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DEANSHIP OF GRADUATE STUDIES

Date
12/1/13

I dedicate this modest work to Allah Almighty for his grace and blessing

I ask him to accept this work and to make it useful

Then I dedicate it to:

Saba the homeland and the human .. The love and the hope

My parents sourcing tender and the reason of my being

My brothers who I relied on them when adversity

My sisters' the headwaters of love and kindliness

My wife my life partner at the moments of happiness and sadness

My daughter which gives me the Permanent smile

My teachers who guide me to the right way

My friends the meaning of Permanent Fidelity

To all of them I dedicate this work with all of my love and appreciation.

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CHAPTER 1

Introduction

Over the last decade, the extensive uses of software have placed new demands on the software industry to enhance development productivity and reduce associated costs [1]. These expectations have led software engineers to apply the idea of reuse [2]. *Software Product Line Engineering* (*SPLE*) is an approach with an aim to move the software industry away from developing each system from scratch. Building systems from the common features rather than building new systems is the key idea in *SPLE* that is because in a certain software domain, systems have more commonalities features than private ones which give companies the ability to release product variants by adding new features [3]. *SPLE* helps to identify common features among similar family of products into core assets, and subsequent applications are developed by reusing these core assets [4, 5].

SPLE has potential to improve productivity and reduce time to market [6, 7]. As shown in *Figure 1.1*; fundamental to *SPLE* success is the need for a core asset which has high degree of reusability [8]. The organization can assemble the core asset base all at once before building any products (a proactive strategy) or incrementally as it introduces products (a reactive strategy) [9]. The reactive approach is like the agile approaches to conventional software where one or more product variations are analyzed and implemented on each development spiral [10].

A key challenge in *SPLE* is to find a right balance between reusability and cost involved in core asset development. The core asset development process needs to maximize the coverage of a product line domain within a budget and a given time frame. We believe that for *Software Product Lines* (*SPL*) to be a part of mainstream software engineering culture, organizations need strategies with low adoption barriers. There is a need that required a small upfront effort, incremental transition from current practices, and a rapid return on investment [10].

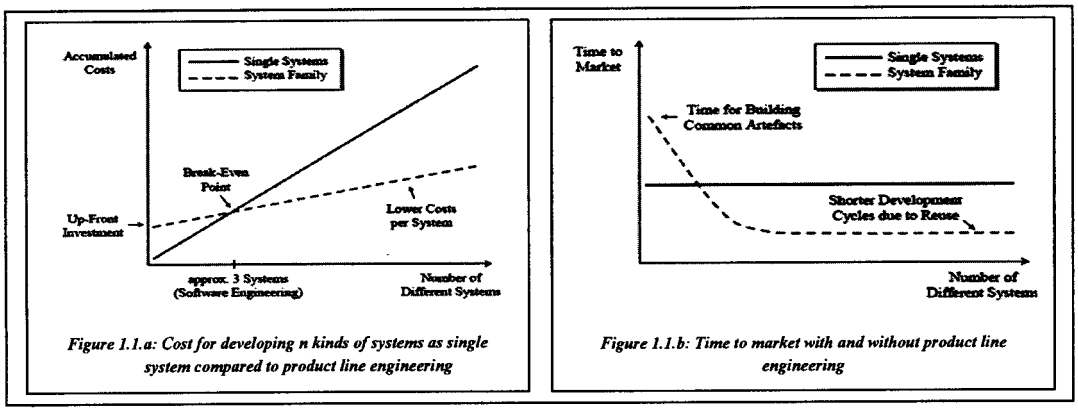

Figure 1.1: SPLE cost and time to market analysis [7]

In this thesis, we present a management framework for *SPLE* that provides quantitative information to evaluate reuse opportunity of software features. The framework helps in handling the uncertainties associated with software feature selection.

1.1 Motivation

SPL development needs a collaborative process whereby organizations can balance the conflicting interests between high reusability demand and lower cost. This process needs to focus on how to achieve the required reusability level; and handle the uncertainties during the product line core asset development.

In this thesis, we develop a management framework for *SPL* core asset development which helps a system analyst to (a) understand feature relationships and their dependencies; (b) quantifies *Reuse Opportunity* of features; and (c) handles the uncertainties within features selection by estimating the potential benefits of including features at different core asset development spirals. Furthermore, we consider the management of *SPL* core asset development from the perspective of *Real Option Theory* (*ROT*), which addresses uncertainty over time and handles selection of features during the development process.

1.2 Research Objectives

The main objective of the thesis is to address the key challenges associated with the *SPL* core asset development process by handling the uncertainty on *SPL* features selection. This main objective can be broken down into number of smaller objectives steps as follow:

- Analyze *SPL* features dependencies relations to classifying these features into a number of *Features Sets*.
- Develop a process to identify *Reuse Opportunities* for the *Features Sets* based on *SPL Marketing Product Plan* (*MPP*) and *Features Sets* dependencies relations.
- Identify *Development Priority* for *SPL Features Sets* in core asset development based on their *Reuse Opportunities*.
- Manage *Software Product Line* core asset development uncertainty based on the *Real Options Theory* concept.
- Analyze the impact of the framework on the *SPL* development based on case studies.

1.3 Research Contribution

As part of this thesis, we develop *Software Product Line Engineering Management Framework* (*K-SPLEMF*) for *SPL* core asset development. The main contributions of our work are:

- Identify a method to classify an *SPL* features into *Features Sets* based on their dependencies relations.
- Introduce a new matrix to calculate *SPL* features and *Features Sets Reuse Opportunities*.
- Prioritize features and features sets in the *SPL* core asset development process using *ROT* concepts.
- Analyze and discuss the results of the framework application on the *SPL* core asset development through the case studies.

1.4 Thesis Organization

The remainder of the thesis is organized into the following chapters:

- **Chapter 2: Literature Survey**

This chapter will go over the body of work that is relevant to our thesis by first covering the basic ideas and general concepts followed by a discussion of the related work.

- **Chapter 3: SPLE Management Framework**

Chapter 3 presents the management framework (*K-SPLEMF*) for *SPL* core asset development, and illustrates the framework phases in details.

- **Chapter 4: Case Studies**

In this chapter *SPL* case studies that were used in the thesis are presented.

- **Chapter 5: Result Analysis and Discussion**

This chapter presents results and discussions for the application of our framework phases on the case studies shown in *Chapter 4*.

- **Chapter 6: Conclusions and Future Work**

The thesis is concluded by summarizing the thesis work as well as discusses the strengths and potential limitations of this work. Furthermore, it provides number of suggestions for further work directions on the topic.

CHAPTER 2

Literature Survey

The research done for writing this thesis can be broken down to two major components, Software Product Line (SPL) and Real Option Theory (ROT). There is a wealth of information on both of these topics individually. But it is their common area which is of particular interest to this thesis, and that area remains relatively unexplored.

The goal of this chapter is to provide some background information on the concepts being discussed in this thesis, as well as offer a comprehensive discussion of the related works.

2.1 Background: Definitions and Overview

In this section, an introduction about *SPL* and *ROT* is presented. The key concepts used in this thesis are illustrated briefly to make the reader more familiar with these concepts.

2.1.1 Software Product Lines (SPL)

The *Software Engineering Institute* (*SEI*) defines *SPL* as "*a set of software-intensive systems that share a common, managed set of features satisfying the specific needs of a particular market segment or mission and that are developed from a common set of core assets in a prescribed way*" [11].

SPL is a family of software applications in a common purpose domain, allocating with a set of common features. Product line variability determines the variety from one application to another [6].

In the early 1990s, software families and product lines concepts came into view. The *Feature-Oriented Domain Analysis* (*FODA*) method description is one of the first contributions in that field [12]. Also, many companies began to deal with this matter more methodically at the same time [13]. This concept (*SPL*) helps companies to develop their products from a core asset instead of starting from the scratch. On the other hand, such as software engineering the development of these assets should utilize the commonality and dial with variability management. Therefore *FODA* approach was become a way to commonality and variability analysis that is used by many researchers in industry and academic [4].

Product line engineering has become an important and widely used approach for efficiently developing portfolios of software products [9]. It is one of the recent and effective reuse approaches [5]. Software product line engineering has gained a broad interest in academic as well as in industry over the past decade [14]. Using *SPL* seeks to maximize reusable variation and eliminate wasteful generic development of components used only once [15]. A number of authors have described the potential benefits that may accrue from using *SPL* techniques in the requirements, architecture, design, coding and testing phases [6, 7, 16].

Variability management is the basic rule in *SPL* that is classified product line components into three types: common, optional and alternative components or features and manage them in the development process. Common features are shared for all products in the family however, alternative is for specific products and optional features could be or not be parts from the products [15].

The reuse of the same assets containing clear variability is the main difference between software product line engineering and other reuse techniques. An example of this is the requirement representations perhaps include a clear description of specific needs which is not applicable to a certain subgroup of products [13].

SPLE is a technique for developing and maintaining products family, taking advantage of their common features and signed variable ones [17]. The commonality and variability exist between the products in a family is the basic structure in the product line [18]. Using *SPLE* in developing product families decreases time and cost, also increases product quality and helps to get customer satisfaction [7, 14].

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