Model-Based Requirements Engineering for Product Lines

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Abstract: Requirements engineering is an important part of software and systems engineering but needs some specific support to apply it to product line engineering. Tracing requirements for different products of the product line to different architecture instantiations and component variants, and to the corresponding design decisions, by using a requirements model can reduce development time significantly. Requirements engineering is used in both the domain engineering and application engineering processes of product line engineering. A good requirements model can support major parts of both, such as commonality analysis and tracing of connections between requirements, architecture, components, and tests. This paper presents our approach for such a model, and show how groups can work in parallel on products of the product family.

1. INTRODUCTION

Siemens is a large, global electrical engineering and electronics company with a very diverse range of product areas (energy, industry, communication, transportation, health care, etc.). Software plays an important and increasing role in many of our products, systems, and industrial plants. Because of the advantages of the product line approach, there is a strong interest in the topic of product lines at the various Siemens business groups. We provide enterprise-wide consulting in requirements engineering, especially its connection to the product line approach [Siemens 99]. This paper presents our approach for a requirements engineering model and shows how working groups can work in parallel on products of the product family.
Product line engineering is based on systematic reuse of all possible artefacts for product design. The efforts for reuse have to start at the very beginning of the life cycle with market analysis and requirements engineering. The major difference between product line engineering and single-product engineering is the division of the life cycle into two parts, domain engineering and application engineering. As pointed out in Clements [Clements 99] and other papers, requirements engineering is an important technology for both parts. Model-based requirements engineering can provide the basis for system development, a model on which domain analysis and application requirements are performed. The model also builds the space where objects can be traced from market analyses to user requirements, design specifications (including design decisions), components, and tests. Such a model has to be incorporated into the design process so that each stakeholder can have a consistent view of the whole state of the project, and inconsistencies occurring during design and implementation can be detected immediately.

Requirements analysis and specification are performed on this model in the domain analysis phase and the application requirements engineering phase (see Figure 1). The model is also the basis for commonality and variability analysis as part of domain analysis. It comprises the objects—requirements and architecture modules, use cases, and component descriptions—that are considered for commonality and variability analysis. Operations on the model can support and enhance methods like FAST (family-oriented abstraction, specification, and translation [FAST 98] and FODA (feature-oriented domain analysis) [FODA 90].

So far there is not much literature about requirements engineering models for product lines. Vinga-Martins [PRAISE 99] describes traceability and an extension of FODA, and Lam presents key practices for requirements engineering for product lines [Lam 99]. The model described herein can be used as basis for requirements engineering, change management, and domain analysis so that the users can work on a consistent model and trace all artefacts of system design.

2. REQUIREMENTS FOR THE MODEL

Working in the field of requirements engineering, it is natural to ask first "what are the requirements?" when you start describing a subject. The most important requirements for a model for supporting product lines are:

- It should support domain engineering, especially commonality and variability analysis.
- There must be (sub-) models for each single product of the product line as basis for product design.