Quality Attributes Modeling in Feature Models and Feature Model Validation in Software Product Lines

A thesis submitted in fulfillment of requirement for the degree of Doctor of Philosophy

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Statement of Originality

The thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to the final version of my thesis being made available worldwide when deposited in the University’s Digital Repository.

Guoheng Zhang
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Abstract

In a software product line, a feature model represents the commonalities and variabilities among a family of software systems. Each valid combination of features authorized by a feature model corresponds to a possible product of the software product line. In feature-based product configuration, the desired features are selected from a feature model based on the customers’ requirements, but the selected features must satisfy the selection constraints specified in the feature model.

In practice, two problems arise as the major obstacles of using feature models in product configuration. Firstly, a feature model may have errors which must be resolved for the effective product configuration. The feature model validation aims to identify the feature model errors and provide explanations for each identified error. The current validation approaches transform a feature model into a constraint satisfaction problem (CSP) and use solvers to reason on the CSP. However, the use of solvers might take an infeasible amount of time for validating large-scale feature models, as CSP exhibits the exponential complexity and requires a combination of heuristics and combinational search methods. A more efficient feature model validation approach is needed. Another problem is to assess the product quality in feature-based product configuration. In software development, the product quality is mostly handled until the final product is generated and tested. However, if the final product cannot satisfy the customers' quality requirements, it will be very costly to fix the problems. Therefore, the product quality should be assessed in feature-based product configuration which is considered as the first stage of deriving valid products. To achieve this aim, the quality attributes must be modelled in a
feature model. The current quality attributes modeling approaches have several limitations, such as requiring real products which are difficult to obtain or involving onerous human efforts. A systematic quality attributes modeling approach is needed to reduce the efforts involved in domain experts’ judgments.

This research aims to address the above problems. First, we developed an efficient validation approach based on the contradictory feature relationships behind the errors. As the contradictory feature relationships were found based on feature relationship propagation, the solvers were not required by this approach. Second, we developed a quality attributes modeling approach which uses domain experts to make judgments and uses analytic hierarchical process to reduce the efforts involved in the judgments. A knowledge database called quality attribute knowledge base is generated to maintain the captured quality knowledge. Finally, we enhanced the feature-based product configuration with the captured quality knowledge. A desired product is configured from a feature model in a quality-aware manner. A prototype tool was developed to implement the concepts of the proposed approaches and a set of empirical experiments were carried out to evaluate the proposed approaches.