복잡한 소프트웨어 제품라인의 다양성 관리를 위한 XML 기반의 기능 모델링

아사드아바스O, 이스마파라시디키, 이욱진

한양대학교 컴퓨터공학과

asadabbas@hanyang.ac.kr, isma2012@hanyang.ac.kr, scottlee@hanyang.ac.kr

XML-based Feature Modeling for Variability Management in Complex Software Product Line

Asad AbbasO, Isma Farah Siddiqui, Scott Uk-Jin Lee

Department of Computer Science and Engineering, Hanyang University

ABSTRACT

The aim of Software Product Line (SPL) is to increase the productivity of software in less time by reusability of resources. Feature modeling is the best paradigm for enhancing reusability. XML-based feature modeling is an effective way to manage the commonalities and variability among various product versions in SPL. In Complex SPL, dependency in between features becomes tangled which make features management challenging, to add new features or remove existing features. In this paper we present management solution for feature variability by using XML-based feature modeling. The proposed solution is supported with case study of automobile features as a complex system.

1. INTRODUCTION

In software development, the competition is increased continuously depending on factors like time, cost and effort. Software Product Line (SPL) deals with family of software products, which is based on reusable platform for development of new products with some variations and commonalities. The basic idea of SPL is to find the common and variant requirements in all software products of the same domain. A main objective of SPL is to manage the features of core assets (reusable resources) for reuse those assets. The major advantages of reusability in SPL are 1) reduction in time-to-market as the number of products increases, 2) reduction in development cost, 3) reduction in development effort of new product [1].

SPL deals with commonalities and variability among different products within the same domain. Commonalities are common features that can be reused in all products without any change. Variability is variant features that differentiate one product from another. Variability is generally modeled with feature diagram [2]. For successful adoption of SPL, management of commonalities and variability is critical issue because of complex and hard binding of features. Among the two, variability management is most critical level because it defines the variation among different products of SPL [3, 4].

Feature Oriented Domain Analysis (FODA) is an effective way to manage commonalities and variability in SPL. It consists of different types of features such as, mandatory features; necessary for product, alternative features; selecting one among various and, optional features [4].

In this paper, an effective management of variability using XML-based feature modeling is proposed. XML can be used for flexible variability modeling of features in SPL. XML schema represents the meta-model of feature model and defines global constraints and rules on features, which provides an effective way to manage and validate features. Variation point in feature modeling is defined by tags and rules applied within schema. XML-based modeling makes it possible to add new or remove existing features in running system [3, 5, 6].

The rest of this paper is organized as follows. In section 2, related research is presented. In section 3, problems related to feature modeling in SPL are described. Section 4, presents proposed solution with case study. Finally, section 5 concludes this paper.

2. RELATED WORK

Variability management is a vital issue in SPL. Feature modeling is an effective way to resolve this issue which many researchers have discussed with different perspectives.

Jeong Ah Kim [3] discussed the management of feature variability by XML. The author classified variability in five distinguished domains and discussed two variability modeling approaches, Ontology-based modeling and XML-based modeling. In product line of insurance, ontology-based variability modeling and rules definition is found to be effective. However, development of variability modeling by adding or removing some features is still considered critical because of complex bindings. To increase reusability in SPL, XML-based variability modeling is more suitable in order to add or remove features.

Li Zheng et al. [5] discussed management of resource repository and presented XML-based interface to validate description. The paper discussed two challenges for resource repository built up, resource description, and resource organization. The organized feature model is then proved to manage commonalties and variability of SPL effectively. For convenient resources description and formal structure, XML-based interface is an appropriate scheme.

Stan Jarzabek et al. [7] discussed about mitigation of preprocessing problems in feature management by using query-based analysis. XVCL (XML-based Variant Configuration Language) handles the variability modeling in SPL. Authors developed a query based feature model with distinguished XVCL.

Aforementioned researches discussed management of resources in SPL with query-based feature management using XML. Our approach presents XML based feature modeling for variability management. The approach shows prominent advantage with existence of huge complexity and dependencies among variations in SPL.

3. FEATURE DEPENDENCY IN COMPLEX SPL

In SPL, reusability of core asset is one of the major parts of production. For increase the reusability, recent research priorities feature modeling [7]. In the sense of complex system, large numbers of variations in features increases difficulty to reuse the assets. Increment in features increases dependencies which causes difficulty in reusability. Large dependency among features results in tangling problem and makes difficult to add new or remove existing features.

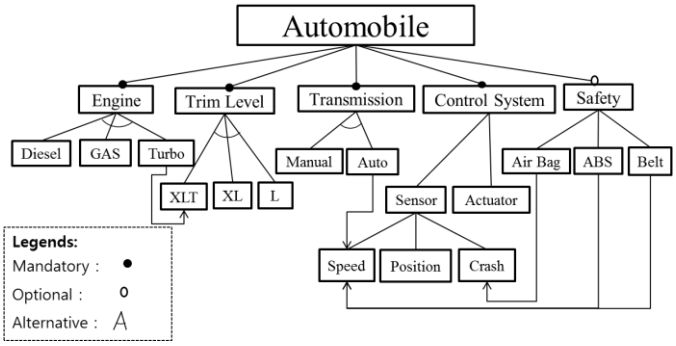

Figure 1. Feature Model of Automobile

Figure1 illustrates a complex feature dependency model for automobile. The model shows features as mandatory, alternative and optional. Safety feature include three features air bag, Auto Brake System (ABS) and, seat belt. Control System include different sensors crash sensor, position sensor and speed sensor. Air bag and speed sensor depends on crash sensor. If we apply any kind of change in crash sensor it will effect on both air bag and speed sensor features. Auto sensor also depends on speed sensor. In the same case if there are large numbers of features which are dependent to each other then it is difficult to manage variability during addition or removal of dependent features.

4. XML-BASED FEATURE MODELING IN COMPLEX SPL

Reusability of SPL assets is more feasible when there is less dependency between features. XML is good for complex SPL where dependency increased between features in running system. For adding new features and ignoring existing features XML is very suitable [5, 6].

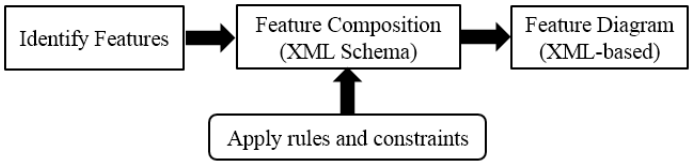

Figure 2. XML-based Feature Variability Management

Figure2 shows process layout for feature variability management using XML. The process starts with identification of features to add in product and next composition of features by using XML-schema with rules definition of modeling and constraints. XML-schema is used for traceable feature meta-modeling. Further, meta-model of XML-schema is validated by feature diagram. In XML-schema features can be modeled separately without affecting each other.

In the case study of automobile mentioned above, we modelled all dependent features individually, which provides high reusability for existing features and flexibility in adding new features. Air bag feature is developed as separate module and used in crash sensor module. Similarly, speed sensor created as a separate module and referred at crash sensor module. Independent modules are feasible in order to make any change without affecting others. XML-based feature modeling facilitates to describe each feature separately by using rules and constraints.

Figure3 depicts XML-based feature model diagram for Automobile. It is clearly shown that all dependent and variable features are defined separately. Dependent features can be concatenated where variability is required in between different versions of SPL. 'EngineType', 'TrimLevel' and 'TransmissionType' are defined as alternative features. 'Sense' and 'Safety' are containing optional features. Features under 'Safety' are dependent on 'Sensor' features.

Another 'Auto' feature under 'Transmission' feature is dependent on 'Trim-Level' feature. XML-based variability specification shows a flexible way to extend the scope of variability without affecting other modules. In XML schema variation points can be defined as rules, which make easy extension for new concepts, relations and constraints for new and existing features.

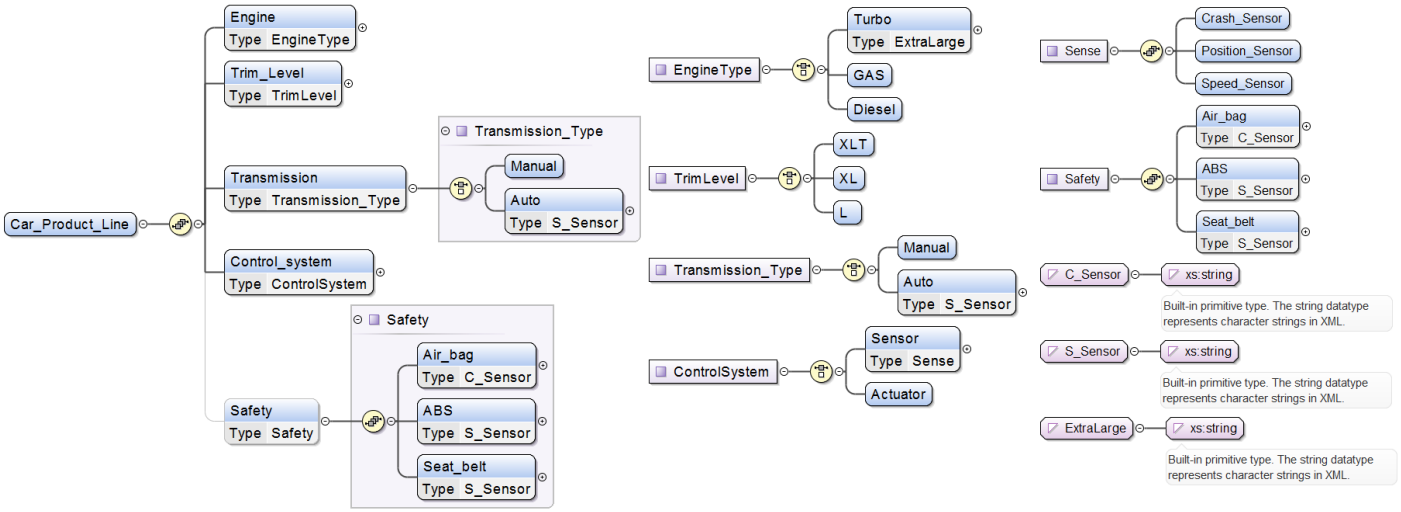

Figure 3. XML-based Feature Model for Automobile

Some major observations from this research are:

- In XML-based meta-model, normalization of feature data is not necessary whereas it is still required in other meta-models.
- XML-based feature model offers a low-cost path for model developments.

5. CONCLUSION

As discussed previously, reusability of core assets in SPL is a complex problem, which can be managed by use of XML-based feature modelling. In complex SPL where dependency is much higher, XML-based specification supports manageable addition and deletion of features in feature model for new product, without effecting overall system. Moreover, XML-based modeling reduces tangled dependency among features and increases reusability without any major change or side effect to overall SPL. XML-schema defines the composition rules and constraints which help to define boundary and reference within features. From results of automobile case study, we found that XML-based feature modeling is easily manageable to apply required constraints among features. Moreover, it reduces risk of errors and simplifies the specification.

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