

## A variable approach to variability management

*-deals with the management of variability in product lines using a model driven approach which is customizable to domain specific needs.*

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### Research questions:

- (i) What are the required capabilities of a variability modelling approach for complex product lines?
- (ii) Can the approach be adapted to different domains?
- (iii) Can variability models be created and maintained using the adapted approach?

Complex systems are frequently not developed for a single customer. Instead, a product line approach is pursued in which the set of products belonging to one product line and targeting a specific market segment are developed from a common set of assets. Product line engineering (PLE) aims to increase the productivity of development and the quality of developed systems through massive reuse. The key to successful reuse is the explicit modelling and management of commonalities and variability of the product line's assets. Variability mechanisms are needed on different levels such as requirements, architecture, or implementation and for heterogeneous and domain-specific artefacts. The creation and management of variability models is however a challenging task. Defining, managing, and evolving a product line requires a large amount of domain-specific knowledge unequally distributed among diverse heterogeneous stakeholders. Current PLE approaches tend to separate the concerns of these activities.

Despite its increasing popularity, the widespread adoption of product line engineering is still hampered by a lack of flexible and extensible approaches that can be tailored to diverse organizational settings such as architectural styles, languages, or modelling notations. Many existing product line approaches focus on process aspects and general-purpose modelling approaches. In our research collaboration with Siemens VAI we have however found a strong need to integrate both stakeholders responsible for different tasks as well as different models and work products. More specifically, we have identified a set of key requirements for a variability modelling and management approach:

- **Tailoring of the approach:** Many existing approaches to PLE are rather rigid and only allow minimal domain-specific adaptations. Setting up a product line and modelling the variability of its assets however differs across diverse organizations and domains due to different concepts, technologies, and rules. A variability management approach thus needs to be customizable to support different types of core assets, architectural styles, or programming language. Tools should be based on flexible meta-models that can be customized as needed.
- **Mining existing assets:** Software product lines often consist of thousands of assets. It should be possible to create initial variability models by automatically extracting information from existing assets. It is also important to automate the detection of changes in the asset base, to expedite the update variability models to ensure their consistency with the asset base.
- **Involving multiple teams:** It is impossible in a large-scale product line for individual engineers or even a small team to create and maintain variability models for the complete system. Instead different teams are in charge of different parts of the product line. Support for the distributed and coordinated creation of variability models by different teams is thus essential. This includes features to resolve conflicts when merging multiple variability models.
- **Guidelines:** PLE is still challenging because of the absence of standards on how product lines should be managed. Creation of such a standard is not trivial as different domains need to deal with their product lines in different ways. When managing a product line, it is however extremely helpful to have guidelines for modelling and implementing variability mechanisms.
- **Supporting product line evolution:** Evolution is a permanent challenge in PLE. The reusable assets evolve continuously due to new customer requirements or technology changes. This leads to modifications or extensions of the product line. Keeping variability models consistent with the evolving assets is complicated. Due to the large size of product lines, single stakeholders or teams can only maintain a small part of a system. Such multi-team environments pose additional challenges for evolution. Existing product line approaches often assume a stable product line environment when defining domain and variability models to ease subsequent reuse and automation. Through the collaboration with our industry partner Siemens VAI we have seen that such stability cannot be taken for granted. Rather, we have observed continuous evolution of the product line in both domain and application engineering activities. We thus believe that PLE should treat evolution as the normal case and not as the exception.
- **Tool-support:** The complexity of today's software systems makes it impossible to deal with them, without proper tool support.