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Software and systems engineering — Methods and tools for variability modelling in software and systems product line

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National foreword

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Ingénierie des systèmes et du logiciel — Méthodes et outils pour modéliser la variabilité dans les gammes de produits des logiciels et systèmes

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 7, *Software and systems engineering*.

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Introduction

Software and Systems Product Line (SSPL) engineering and management creates, exploits and manages a common platform to develop a family of products (e.g. software products, systems architectures) at lower cost, reduced time to market and with better quality. As a result, it has gained increasing global attention since the 1990s.

Variability, which differentiates a member product from other products within a product line, plays an important role in SSPL; and hundreds of variabilities are introduced throughout the whole SSPL domain engineering stages. Those variabilities are defined, refined, newly added as domain engineering stages go forward. Variabilities thus are modelled carefully so as to manage and control them in a systematic way. This document deals with methods and tools capability for supporting variability modelling using consistent notations and for managing and/or utilizing variability models in domain and application engineering lifecycle processes.

This document can be used in the following modes:

— by the users of this document: to benefit people who want to adopt SSPL for producing their products by guiding how to model variabilities among member products;

— by a product line organization: to provide guidance in the evaluation and selection for methods and tools for variability modelling;

— by providers of tools and methods: to provide guidance in implementing or developing methods and tools by providing a comprehensive set of methods and tools capabilities for supporting variability modelling.

The ISO/IEC 26550 family of standards addresses both engineering and management processes and capabilities of methods and tools in terms of the key characteristics of product line development. This document provides processes and capabilities of methods and tools for variability modelling in product lines. Other ISO/IEC 26550 family of standards are as follows:

— processes and capabilities of methods and tools for domain requirements engineering and application requirements engineering are provided in ISO/IEC 26551;

— processes and capabilities of methods and tools for domain design and application design are provided in ISO/IEC 26552;

— processes and capabilities of methods and tools for domain realization and application realization are provided in ISO/IEC 26553 (International Standard under development);

— processes and capabilities of methods and tools for domain testing and application testing are provided in ISO/IEC 26554;

— processes and capabilities of methods and tools for technical management are provided in ISO/IEC 26555;

— processes and capabilities of methods and tools for organizational management are provided in ISO/IEC 26556;

— processes and capabilities of methods and tools for variability mechanisms are provided in ISO/IEC 26557;

— processes and capabilities of methods and tools for variability traceability are provided in ISO/IEC 26559;

— processes and capabilities of methods and tools for product management are provided in ISO/IEC 26560;

— processes and capabilities of methods and tools for technical probe are provided in ISO/IEC 26561;

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— processes and capabilities of methods and tools for transition management are provided in ISO/IEC 26562;

— processes and capabilities of methods and tools for configuration management of asset are provided in ISO/IEC 26563;

— others (ISO/IEC 26564 to ISO/IEC 26599): to be developed.

ISO/IEC 26550, ISO/IEC 26551 and ISO/IEC 26555 are published. ISO/IEC 26557 and ISO/IEC 26559 are to be published. ISO/IEC 26552, ISO/IEC 26553, ISO/IEC 26554, ISO/IEC 26556, ISO/IEC 26560, ISO/IEC 26561, ISO/IEC 26562, ISO/IEC 26563 are planned International Standards.

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Software and systems engineering — Methods and tools for variability modelling in software and systems product line

1 Scope

This document, within the context of methods and tools for supporting explicit and/or separate variability modelling, variability model management and variability model support in software and systems product lines:

— provides the terms and definitions specific to variability modelling for software and systems product line;

— defines processes for variability modelling, variability model management and variability model support throughout the product line lifecycle. Those processes are described in terms of purpose, inputs, tasks and outcomes;

— defines method capabilities to support the defined tasks of each process;

— defines tool capabilities that automate or semi-automate tasks and methods.

This document does not concern processes and capabilities of tools and methods for a single system but rather deals with those for a family of products.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
application configuration
composition results of an application by both binding variability and adding application specific variability

3.2
application variability model
variability model for a particular application including variability binding results, application specifically modified variability and application specifically added variability

3.3
aspect
special consideration within product line engineering process groups and tasks to which we can associate specialized methods and tools

3.4
domain variability model
explicit definition of product line variability

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3.5
constraints dependency
relationship between *variation points* (3.12), between *variants* (3.11) and between a variation point and a variant

Note 1 to entry: Two types of constraints are possible: "excludes" which means a variant or a variation point forbids another variant or variation point and "requires" which means a variant or a variation point demands (an-)other variant or variation point.

3.6
texture
architectural texture
collection of common development rules and constraints for realizing the applications of a product line

3.7
variability dependency
association from a *variation point* (3.12) to a *variant* (3.11) or variants

3.8
variability modelling
explicit definition for product line variability

3.9
variability modelling plan
documentation that includes schedules, defined roles and responsibilities, and defined quality assurance measures that will be applied to *variability modelling* (3.8)

3.10
variability modelling strategy
variability modelling (3.8) methodology, strictness degree of variability model validation, rules, constraints, other details for supporting the role of variability model in the whole variability management

3.11
variant
instance or a value of a *variation point* (3.12)

3.12
variation point
indication of product differentiation based on particular variable characteristics of products, domain assets, and application assets in the context of a product line

4 Variability modelling in software and systems product line

4.1 Overview

Variability is a key differentiator between single-system engineering and management and product line engineering and management. Product line engineering and management has to take explicitly into account the variations within and between multiple products. The product line variabilities are introduced and defined during product management, domain engineering and application engineering processes defined in ISO/IEC 26550. Their abstraction levels at each lifecycle stage can differ and much variability are refined or newly added as the development progresses. Variability should be defined, modelled, implemented, versioned, verified and validated. Variability model supports abstractions and explicit expressions of the defined variabilities. Variability modelling means the operation for creating, maintaining and supporting variability models using variability together with variability-relevant information defined from product management, domain engineering to application engineering of ISO/IEC 26550. This document supports variability modelling using consistent notations and provides management and required supports for managing and/or utilizing variability models in domain and application engineering.

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There are two types of variability models: domain variability models and application variability models. Domain engineering typically provides most of the variability information necessary for structuring the domain variability model. The model is refined and managed throughout the domain engineering lifecycle. On the other hand, application-specific variabilities are introduced during application engineering because each member product of a product line may offer plenty of variability for differentiating itself from other products. Application-specific variabilities including the bound variability of domain variability model are documented as an application variability model. This model is also refined throughout the application engineering lifecycle. The levels of detail of variability information differ depending on the process (e.g. application requirements engineering) where the information is produced.

The orthogonal variability model (OVM) defines the variability of a product line separately unlike feature model that defines the whole domain including both commonality and variability or integrated modelling approach that represents variability by integrating within the development artefacts. A typical product line has hundreds of variability, so it is difficult to manage (i.e. tracing, changing and so on) variability in the forms of feature model or integrated modelling approach. For defining the variability orthogonally, some types of variability dependency, variability constraints and the elements consisting model may be used as it is, or some of them should be defined differently or newly added. This clause describes the elements of the OVM.

The variability consists of the following elements, so the OVM that models the variability should include the following elements:

— variation point;

— variant;

— variability dependency.

A variation point should have relations with more than one variant. The basic variability dependencies include the following:

— mandatory: a variant should be selected, namely it should be part of a member product if the corresponding variation point is selected;

— optional: a variant can be selected or not, namely it can be part of a member product or not.

Optional variability dependency has the following special types of variability dependency:

— exclusive-or, alternative: only one variant should be selected among variants that have optional variability dependency with the same variation point;

— inclusive-or: numbers of variants can be selected among variants that have optional variability dependency with the same variation point, and the numbers of variants that can be selected are defined by range.

Variability can have relations with other variability. The selection of a variation point or a variant can constrain other selections of a variation point or a variant. Such restrictions are called constraint dependency. Constraint dependency includes the following types:

— requires: a variation point or a variant requires another selection of a variation point or a variant;

— excludes: a variation point or a variant should not be selected when a variation point or a variant is selected.

NOTE 1 The principles of variability in SSPL and the orthogonal variability model are depicted in Annex A and Annex B.

NOTE 2 Formal descriptions for the variability dependency and constraints dependency are depicted in Annex C.

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4.2 Reference model for variability modelling in software and systems product line

The reference model specifies the structure of supporting processes and subprocesses for variability modelling in product line. As shown in Figure 1, variability modelling in product line can be structured into three processes: variability model management, variability modelling and variability model support. In the rest of this document, tasks, methods and tools are described in terms of processes and subprocesses defined in the reference model.

Each process is divided into subprocesses and each subprocess is described in terms of the following attributes:

— the title of the subprocess;

— the purpose of the subprocess;

— the inputs to produce the outcomes;

— the tasks to achieve the outcomes;

— the outcomes of the subprocess;

— the capabilities of methods and tools required for performing the tasks effectively and efficiently.

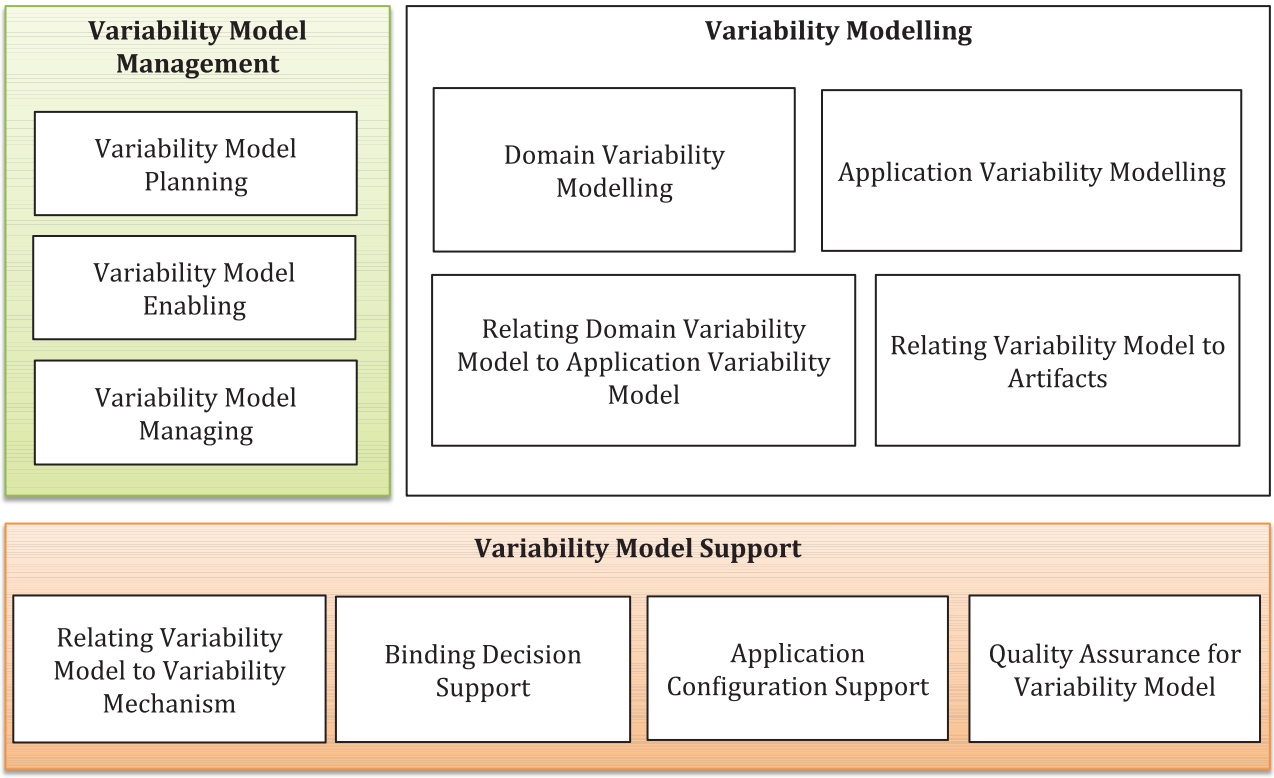

Figure 1 — Variability modelling in SSPL

The variability modelling management process provides managerial supports for planning variability modelling (e.g. variability model elements, variability model notation, resource estimation, responsibility allocation, quality assurance measures), supports for providing necessary resources, tools and infrastructures for realizing variability modelling plans and supports for analysing the plan versus actual status of variability modelling realization status. Variability modelling management shall do the following:

— variability model planning;

— variability model enabling;

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— variability model managing.

The variability modelling process supports variability modelling for identifying and visualizing all variabilities and their relationships, for visualizing detailed relations from variability models to domain/application assets and for visualizing relations between two variability models, namely domain and application variability models. Variability modelling shall do the following:

— domain variability modelling;

— application variability modelling;

— relating domain variability model to application variability model;

— relating variability model to artefacts.

The variability model support process provides supports required for establishing the right variability models and for establishing the right roles of variability models, i.e. establishing and maintaining the detailed relations from variability model to variability mechanisms, binding supports and application configuration supports. Variability model support shall do the following:

— relating variability model to variability mechanism;

— binding decision support;

— application configuration support;

— quality assurance for variability model.

The identification and analysis of the key differentiators between single-system engineering and management and product line engineering and management can help organizations to understand the product line and to formulate a strategy for successful implementation of product line engineering and management. The key aspects have been defined in ISO/IEC 26550 and Table 1 shows the category of the key aspects.

Table 1 — Key aspects for identifying product line-specific variability modelling tasks

Category	Aspects
Reuse management	Application engineering, domain assets, domain engineering, product management, platform, reusability
Variability management	Binding, variability
Complexity management	Collaboration, configuration, enabling technology support, reference architecture, texture, traceability
Quality management	Measurement and tracking, cross functional verification and validation

The following are the descriptions for each aspect concerning variability modelling for product lines. The variability modelling relevant processes and tasks shall be identified on the basis of these aspects. The concerns specific to variability modelling for product lines will enable an organization to understand the variability modelling relevant processes, subprocesses, tasks, methods and tools' capabilities.

— Application engineering: Application engineering uses variability model in order to determine the values [variant(s)] of variability and adds application-specific variabilities. Application engineering produces application variability model as the results of those activities.

— Binding: Variability model should devise for providing detailed information required for the right binding. Decision table or annotation can be ways to resolve this.

— Collaboration: Variability model provides the integrated view of the whole variabilities defined and managed in a product line. Domain engineering and application engineering collaborate with each other revolving around variability model for defining, binding and managing variabilities.

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— Configuration: Configuration is produced through binding variabilities defined in variability model. Configuration is produced from architecture stage through runtime, so variability model should be defined having different level of abstraction in accordance with the binding information that variability model should contain.

— Domain asset: Domain assets include variability-relevant implementations. Variabilities within domain assets shall be uniquely identified because there are hundreds of variabilities and it is essential to visualize them for their proper management and efficient application of a product line.

— Domain engineering: During domain engineering, domain variability model is produced.

— Enabling technology support: Technologies for managing domain variability model, application variability model and essential information for the right binding should be supported.

— Measurement and tracking: The optimality and sufficiency of variability model for supporting binding decision and product line maintenance and evolution should be measured and tracked.

— Platform: Platform should include the proper implementation of variation points that enable variability binding. Variation points of a variability model should have links with these parts of a platform.

— Product management: Variabilities defined in a variability model are continuously changed and evolved. Variability model is thus changed and evolved so the major focus of product management should be on the defined variability of a variability model.

— Reference architecture: Reference architecture in a product line should be the structure of handling variability well and evolutionary. Thus, reference architecture should be harmonized with variability model and its evolution.

— Reusability: Variability model should be reusable in order to ensure consistency and extensibility of products within the product line.

— Texture: Texture provides rules and constraints that support correct and consistent implementation of variability defined in variability model.

— Traceability: Trace links between domain variability model and domain assets, between application variability model and application assets and between domain variability model and application variability model should be established and managed.

— Cross functional validation and verification: Correctness and consistency of domain and application variability models are validated and verified.

— Variability: The whole variabilities of a product line should be managed through the variability model, i.e. domain variability model and application variability model.

5 Variability model management

5.1 General

Variability models should be modelled in complete and consistent ways so that the whole variability of a product line is modelled and managed through the explicitly defined variability models. Variability model management should generate plans, provide enabling environments, monitor and control their status.

The variability model management process includes the following subprocesses:

— variability model planning;

— variability model enabling;

— variability model management.

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