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Software and systems engineering — Tools and methods for product line technical management

Ingénierie du logiciel et des systèmes — Outils et méthodes pour le management technique des gammes de produits

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Contents

Page

Foreword

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/IEC JTC 1, *Information technology*, Subcommittee SC 7, *Systems and software engineering*.

This second edition cancels and replaces the first edition (ISO/IEC 26555:2013), of which it constitutes a minor revision.

Introduction

The major purpose of this International Standard is to deal with the capabilities of tools and methods of software and systems product line (SSPL) Technical Management. This International Standard defines how the tools and methods can support for the software and systems product line-specific technical management processes. Since product lines deal with multiple products that have similarities, product lines have an unprecedented level of technical management complexities. This arises from the following sources:

— There are inherent differences in technical considerations because there are parallel development processes, domain and application engineering, in a product line and the two processes are tightly related with each other around assets.

— The close relationships among domain engineering, application engineering, and assets require the highly matured managerial capabilities for addressing relationships among them.

— There are lack of tools and methods to support the product line-specific technical management.

Technical management provides management support for a timely and proper deployment of product line in balance with pre-defined product line objectives such as reusability, reducing cost, improving quality, etc., as well as its planned cost, schedule, and resources. Technical management addresses actual means used to support, monitor, and control the activities of both domain engineering and application engineering of a product line.

There are needs for defining product line-specific technical management processes that integrate the involved product line disciplines with those for a single product. Furthermore, support of tools and methods are required so that a product line organization can perform technical management under the systematic control of complexities. This International Standard addresses the product line-specific processes in technical management by dividing those into *process management, variability management, asset management, and support management* areas with the guidance of a set of tools and methods capabilities for supporting tasks for product line technical management.

This International Standard is intended to benefit people who acquire, supply, develop, operate, and maintain tools and methods for product line technical management. This International Standard can be used in one or more of the following modes:

— By an organization intended to implement product lines—to understand, adopt, and enact the processes, tools, and methods for product line technical management. This also helps the organization to evaluate and select relevant tools and methods based on business and user-related criteria.

— By a tool vendor who facilitates or leverages product line engineering practices—to provide a set of tool capabilities that should be embodied in a tool for supporting product line technical management.

ISO/IEC 26550 addresses both engineering and management processes and covers the key characteristics of product line development. ISO/IEC 26550 provides an overview of the consecutive international standards (i.e. ISO/IEC 26551 to ISO/IEC 26556), as well as the structure of the model:

— Processes and capabilities of methods and tools for product line scoping, domain requirements engineering, and application requirements engineering are provided as ISO/IEC 26551.

— Processes and capabilities of methods and tools for domain design and application design are provided as ISO/IEC 26552.

— Processes and capabilities of methods and tools for domain realization and application realization are provided as ISO/IEC 26553.

— Processes and capabilities of methods and tools for domain verification and validation and application verification and validation are provided in ISO/IEC 26554.

— Processes and capabilities of methods and tools for technical management are provided in this International Standard.

— Processes and capabilities of methods and tools for organizational management are provided in this International Standard.

Software and systems engineering — Tools and methods for product line technical management

1 Scope

This International Standard deals with the tools and methods of technical management for software products, software services, software-intensive systems (including System Architecture and excluding hardware) within a product line. The scope of this International Standard is as follows:

— Enable the users of this standard to holistically understand, adopt, and enact the processes, tools, and methods for product line technical management. In addition, this International Standard helps the users evaluate and select relevant tools and methods based on business and user-related criteria.

— Help product line engineers, developers, and tool vendors become informed about capabilities of tools and methods that are required for supporting product line implementation from technical aspects.

— Provide product line-specific processes and capabilities of tools and methods in technical management.

This International Standard does not concern processes and capabilities of tools and methods for technical management for a one-of-a-kind system but rather deals with those belonging to a family of systems.

NOTE System Architecture is a set of logical and physical principles used to achieve a mission within a given environment. From System Architecture are derived components that can be subsystems, software products, human-based products like crew or operators or hardware product like mechanical structures, electronic boards, chemicals, etc. The scope of the International Standard spans from the system, to sub-systems, and software products. Other types of components and especially those related to human beings and to hardware parts are not within the scope of this International Standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

There are no normative references cited in this document.

3 Terms and definitions

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

3.1
application engineering process
processes for developing a member product in a product line

3.2
attached process
process definitions how each asset will be used in application

Note 1 to entry: The set of attached processes are those for orchestrating the assets together into a coherent whole application.

3.3
binding time
moment of variability resolution

3.4
external variability
variability that is visible to customers

3.5
domain engineering process
processes for domain asset development

3.6
internal variability
variability defined from an engineer's perspective and is not visible to customers

3.7
variability binding
act of determining the variant of the variation point defined in the variability model

3.8
variability documentation
detailed description of variability models for being used across the member products within a product line

3.9
variability in space
variation that occurs at the same time with different shape

3.10
variability in time
variation that occurs at different times

3.11
variability mechanism
variability implementation methods in a product line for supporting assembly of domain assets

3.12
variability traceability
trace links established for a variability model both with domain assets and with application assets where variants are bound.

4 Reference model for product line technical management

The technical management provides processes for addressing technical issues that arise during implementation of a product line, deployment of processes, and development of assets and products within a product line in balance with accomplishing the objectives of a product line, the given costs, schedule, and so forth. Technical management process group deals with variability management, asset management, process management, support management process for managing technical capabilities, resources, issues, and skills that are required for successful implementation of product lines.

Tools and methods in technical management support the systematic development of product lines. Because of profound complexity of product lines, proper tool support for domain engineering lifecycle, application engineering lifecycle, technical management, and organizational management should be provided so that a product line organization can control the technical complexities.

The reference model for technical management in Figure 1 is structured into four processes: process management, variability management, asset management, and support management. 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 tools and methods are a list of the required support of tools and methods for performing the tasks properly.

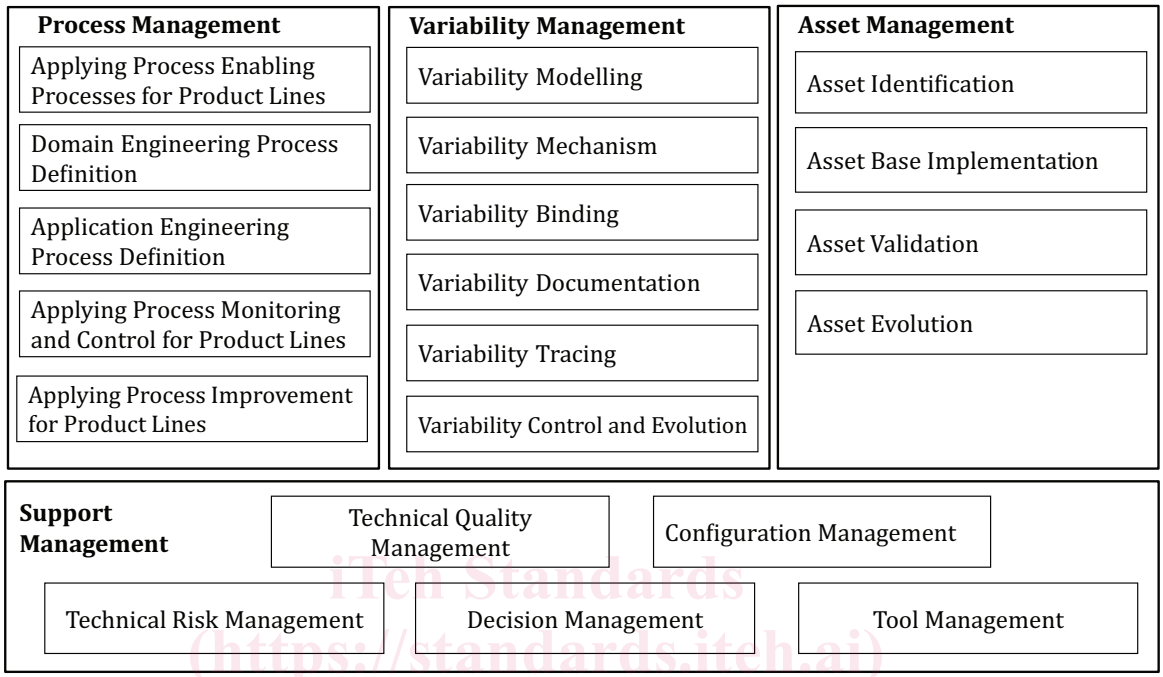

Figure 1 — Product line technical management

Product line technical management shall be conducted from a multidimensional viewpoint that is domain and application engineering. As managerial targets vary according to each viewpoint, management processes for each of them differ. Moreover, assets are used across all applications, and hence, applications within a product line shall share common processes for deriving their applications from assets.

Product line development tends to be performed in a parallel or distributed manner, and therefore technical management processes and related capabilities of tools/methods should be defined by considering these aspects. As for variabilities, they can be managed orthogonally in order to avoid complexity of a product line. Variabilities can be managed orthogonally in order to avoid complexity of a product line. Therefore, the modeling and evolution of variabilities and their traceabilities with domain/application assets should be engineered systematically balancing with its cost, effectiveness, and supported over the product line life cycle.

Project processes and software support processes provided in ISO/IEC 12207 are compatible with the technical management dealt in this International Standard. However, the life cycle model management process that is categorized in organizational project-enabling processes provided in ISO/IEC 12207 is addressed in the process management part of this International Standard.

Because there are collaborations among groups of people in engineering and managing product lines, some relevant processes shall support these collaborations. Process management process serves for establishing and managing a product line organization's capabilities of implementing product line processes. It shall serve to do the following and to define the capabilities of tools and methods for related support:

— *Applying process enabling processes for product lines* addresses the organization's capabilities for initiation, execution, control, and improvement of product line processes.

— *Domain engineering process definition* establishes and maintains domain engineering processes for product line platform development.

— *Application engineering process definition* defines and maintains application specific processes for developing each application based on product line platform.

— *Applying process monitoring and control for product lines* aims to align domain/application engineering processes to achieve product line goals and objectives.

— *Applying process improvement for product lines* serves for the assessment and improvement of domain/application engineering processes.

Variability throughout the domain and application engineering lifecycle processes of a product line should be managed properly. Variability management process defines how member products in a product line can vary and includes variability model management and the explicit documentation of variability. Variability management process shall serve to do the following and to define the capabilities of tools and methods for related support:

— *Variability modelling* supports to maintain the integrity of domain variability model and application variability models.

— *Variability mechanism* supports to realize the variability of a product line in accordance with the determined binding times, rules and constraints, and domain artifacts.

— *Variability binding* maintains necessary binding information to achieve the efficient development of a member product and proactive reuse of product line platform.

— *Variability documentation* supports detailed descriptions of variability models to provide the rationales of variability related decisions.

— *Variability tracing* establishes and maintains trace links between elements of the variability model and the associated domain/application assets.

— *Variability control and evolution* deals with change requests, change impact analysis, change execution, and verification/validation for the change.

The asset management process covers the establishment of asset base and change management for the assets. Domain engineering is responsible for creating and maintaining the reusable domain assets that are stored and managed in the asset base. It also manages the application assets that are worth generalizing and incorporating into domain assets. Asset management process includes management activities for application assets produced and maintained for each member product in a product line. Asset management process shall serve to do the following and to define the capabilities of tools and methods for related support:

— *Asset identification* selects asset candidates (e.g. features, models, specifications, and test cases) developed in domain/application engineering.

— *Asset base implementation* configures the structure of domain/application assets and makes them easy to mine, retrieve, and manage.

— *Asset validation* aims to assure whether the defined strategy of asset structure has been reflected.

— *Asset evolution* serves to deal with change requests from domain and application lifecycle processes.

Support management process deals with generic subprocesses that support the implementation, qualification, and automation/semi-automation of other processes. This includes subprocesses that can be generally applied across the product line organization. Support management process shall serve to do the following and to define the capabilities of tools and methods for related support:

— *Technical quality management* provides assurance about whether assets from domain and application engineering comply with predefined quality criteria and whether domain and application engineering processes comply with predefined provisions.

— *Configuration management* controls the configurations of product line platform as well as configurations of each member product in a product line.

— *Decision management* aims to select the best option where alternatives exist. Quantitative criteria should be considered to achieve an objective decision.

— *Technical risk management* deals with risk identification, assessment, prioritization, and mitigation to prevent failures that inhibit the achievement of business values and product line objectives.

— *Tool management* serves to improve productivity and quality by automation or semi-automation of domain engineering, application engineering, technical management, and organizational management processes.

The identification and analysis of the aspects involved in product line technical management process group will enable an organization to understand the technical management process group and to formulate a strategy for the successful implementation of a product line. The technical management process group shall be defined from these aspects and product line-specific tasks shall be identified on the basis of these aspects.

Table 1 shows the key aspects for each characteristic of product line technical management process group:

Table 1 — Key aspects for identifying product line-specific technical management tasks

Category	Aspects
Reuse management	application engineering, assets, domain engineering, product management, platform, reusability
Variability management	binding, variability
Complexity management	collaboration, configuration, domain architecture, enabling technology support, texture, traceability
Quality management	measurement and tracking, verification and validation

— *Application engineering:* Application engineering processes provide processes for developing applications based on assets. Discrimination of domain and application engineering processes is a unique technical aspect of product line development.

— *Asset:* Technical management provides managerial capabilities necessary for managing assets. Asset management is a distinguished aspect of product line development.

— *Binding:* Technical management serves to prepare sufficient information necessary to bind variants, so that each application can focus on only on application specific parts. Variability binding is an aspect that distinguishes technical management of the product line development from that of single product development.

— *Collaboration:* Collaboration is essential in a product line because product line engineering uses artifacts or products developed in different organization units. Technical management enables that people do their technical roles and responsibilities within agreed-on commitments.

— *Configuration:* Configurations of assets for a product line are distinguished technical aspects of product line development. Maintaining integrity of assets is an important aspect. Configurations of products and artifacts of a product line can be multidimensional, i.e. exist in time and space.

— *Domain architecture:* Technical management enables the decision for obtaining individual component assets of the domain architecture.

— *Domain engineering:* Domain engineering processes are a technical aspect that distinguishes product line development from single product development.

— *Enabling technology support:* Enabling technologies for supporting efficient reuse and management of variability and assets distinguish from single product development.

— *Measurement and tracking:* Technical management defines tasks, tool capabilities, and method capabilities for the product line measurement and tracking. The performance of the product line processes should be measured aligning with the overall product line objectives. The measurement results should be collected, and they shall be used to control product lines for the better achievement of the product line objectives.

— *Platform*: Technical management enables the development of a platform and the development of applications based on the platform.

— *Product management:* Product management should have capability for defining and analysing the measures that make it possible to evaluate designed reusability and productivity and thereafter coordinate a product line towards achieving its goals. These are possible under the support of technical management.

— *Reusability:* Technical management monitors and controls whether the desired level of reusability is achieved in a product line. Providing managerial support for achieving desired level of reusability is a key aspect peculiar to product line development.

— *Texture:* Technical management enables that application can obey the rules defined in textures. Managerial support for obeying textures are dealt in technical management.

— *Traceability:* There exist trace links for asset management and variability management in technical management.

— *Validation and verification:* Validation and verification of assets, platform, and variability model are an aspect that distinguishes product line development from single development.

— *Variability:* Technical management provides managerial capabilities for variability. Variability management is a distinguished aspect of product line development.

5 Process management

Because product line requires a group of people working together and calls for repeated, ongoing, disciplined interactions among separate organizational units, it is essential to make participants adhere a process. Product line engineering relies on a high quality process definition and its effective enactment to achieve required fidelity. In particular, because changes on assets impact more than one application, configuration and changes should be controlled in a disciplined way and asset developers should follow the disciplines carefully. The subprocesses of process management are as follows:

— *Applying process enabling processes for product lines* serves to ensure the readiness for product line process. This subprocess provides capabilities for establishing product line process leadership, resources, and collaboration environment, and supporting product line process assessment and improvement.

— *Domain engineering process definition* serves to define the commonly used processes within a product line and make the participants share them. This subprocess is composed of tasks such as defining, validating, and deploying domain engineering processes.

— *Application engineering process definition* serves to define the application specific processes for developing applications within a product line context. Application engineering processes address how application developers develop their applications based on platform, assets, and variability models. Application engineering processes should be tailored (if necessary) or harmonized with domain engineering processes for right use of assets.

— *Applying process monitoring and control for product lines* serves to measure the performance of processes and if necessary, planning corrective actions to resolve problems for fixing the deviations. Processes for identifying measurement objectives and process-performance objectives

