Metrics for Analyzing Variability and Its Implementation in Software Product Lines: A Systematic Literature Review

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Abstract: This summary refers to the paper Metrics for analyzing variability and its implementation in software product lines: A systematic literature review [EYS19]. The paper was online first in 2018 and was finally published 2019 in the Information and Software Technology (IST) journal.

The use of metrics for assessing software products and their qualities is well established in traditional software engineering. However, such traditional metrics are typically not applicable to Software Product Line (SPL) engineering as they do not address variability management, a key part of product line engineering. Over time, various specialized product line metrics for SPLs have been described in literature, but no systematic description of these metrics and their characteristics is currently available.

This paper presents a systematic literature review, where we identify metrics explicitly designed for variability models, code artifacts, and metrics taking both kinds of artifacts into account. This captures the core of variability management for product lines. We discovered 42 relevant papers reporting 147 metrics intended to measure various aspects of variability models or code artifacts. We provide a categorization of these metrics and discuss problematic issues regarding the definition of the metrics. We also systematically assess the evaluation status of the metrics showing a current lack of high-quality evaluation in the field. Researchers and practitioners can benefit from the published catalog of variability-aware metrics and the assessment of their evaluation status.

Keywords: Software Product Lines; SPL; Metrics; Implementation; Systematic Literature Review

In software engineering, software metrics are an established approach to characterize properties of software [FB14]. However, such traditional metrics are typically not applicable to Software Product Line (SPL) engineering as they do not address variability management, a key part of product line engineering. Over time, various specialized product line metrics for SPLs have been described in literature, but no systematic description of these metrics and their characteristics is currently available.

In [EYS19], we present a systematic literature review to identify and characterize variability-aware metrics designed for the needs of SPLs. Our study aims at identifying existing metrics as a basis to draw qualitative conclusions on implementation properties of product lines. We include variability model metrics, because they are linked to all levels of product

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line realization, including implementation. Thus, we focus only on variability model metrics and code metrics that take variation points into account to characterize product line implementation to answer the following research questions:

**RQ1** Which metrics have been defined for variability models and implementation artifacts of SPLs?

**RQ2** Which correlations between these measures and quality characteristics of product lines have been studied?

We discovered 42 peer-reviewed articles from the last decade to answer **RQ1**. We identified 57 variability model metrics, 34 annotation-based code metrics, 46 code metrics specific to composition-based implementation techniques, and 10 metrics integrating information from variability model and code artifacts. However, only 53 out of 147 metrics (≈36%) have been evaluated in 14 out of 42 identified papers. This indicates that the product line community has only little knowledge regarding to what extend the existing metrics may be used to draw qualitative conclusions over the studied systems (**RQ2**).

The paper presents a description of the identified metrics, examples, and their intended purpose to provide practitioners and researchers with a catalog of the state of the art of variability-aware implementation metrics. Further, we discuss our key observations, which we made while surveying the literature. These are: There is only a weak connection to established metrics from traditional software engineering, the weak use of related work leads to redundant definitions of similar metrics, there are ambiguous metric definitions and problematic evaluations are used. Finally, we were surprised that there exist only a very small number of metrics combining variability information from multiple sources. We found only one empirical analysis evaluating such metrics combining the information from variability model and implementation artifacts. This study indicates a high usefulness of such a combined metric, encouraging further research along these lines.

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**References**
