

## Variability-aware smells: Experimental study protocol

In order to collect further evidence and expand the knowledge on the proposed variability-aware smells (Poor annotation trace, Redundant annotation, Unnecessary annotation, Bad annotation name, and Lack of annotation) in projects implemented by `#ifdef` directives (Conditional Compilation), we present an experimental validation study protocol to be performed in an industry setting.

### 1. Goal

The goal of the experimental study is strengthen evidence of the proposed variability-aware smells in the context of professional software developers. Moreover, this study want to investigate if there is difference on variability-aware smells perception among the inspector profiles (software development experience and programming language).

The objectives of this experimental validation are:

*Objective 1:* Validate occurrences of the proposed variability-aware smells in the studied SPL projects.

*Objective 2:* Investigate the impact of these smells on the quality attributes Program Comprehension, Maintainability, and Evolvability.

*Objective 3:* Investigate if the software development experience and main programming language of the developer are related to developer's variability-aware smell detection abilities.

### 2. Research Question and Metrics

- RQ1. What is the developer perception and opinion about the proposed variability-aware smells? (Objective 1 and 2)
- RQ2. Is there difference in variability-aware smell detection among developer profiles? (Objective 3)
  - RQ2.1. Is there a difference in variability-aware smell detection between full and senior developers?
  - RQ2.2. Is there a difference in variability-aware smell detection between Java and Non-Java developers?

*Metric 1:* Precision of variability-aware smell occurrences detected per participant.

*Metric 2: Effectiveness of variability-aware smell occurrences detected per participant.*

*Metric 3: Efficiency on variability-aware smell occurrences detection per participant.*

The **Precision** of the variability-aware smell detected is calculated through Equation 1, where the **truepositivesmells** variable represents the number of true positive smells identified, and the **totalreportedsmells** variable represents the total number of variability-aware smells reported by participants.

Equation 1

$$\frac{truepositivesmells}{totalreportedsmells} \times 100\%$$

The **Effectiveness** of the variability-aware smell detected is calculated through, where the **identifiedsmells** variable represents the number of true positive smells identified, and the **totalsmells** variable represents the total number of known variability-aware smells, based on the current variability-aware smell occurrence oracle version for each proposed smell in the SPL projects inspected.

Equation 2

$$\frac{identifiedsmells}{totalsmells} \times 100\%$$

The **Efficiency** of the variability-aware smell detection is calculated through Equation, where the **identifiedsmells** variable represents the number of true positive smells identified, and the **time** variable represents the total time spent to detect true positive variability-aware smells.

Equation 3

$$\frac{identifiedsmells}{time}$$

### 3. Analysis Mechanism

To undertake the experimental study research questions, the following analysis mechanisms for the collected data were adopted:

- Comparison between smell occurrences reported from participants (inspectors) of the study and smells occurrences previously recorded in the variability-aware smell

oracle.

- Verification and removal of false-positive variability smells occurrences reported by the inspectors.
- Verification of new entrance of variability-aware smell occurrence not previously recorded.

#### **4. Experiment Preparation and Procedure**

The experiment instrumentation follows four basic steps, described next.

- *Step 1: Variability-Aware Smell Training:* in this activity, participants attended an introductory training about variability-aware smells and variability-aware smells detection.
- *Step 2: Variability-Aware Smell Detection:* in this step, participants review the SPL project feature models and source codes. At the end of this activity, participants send the detection report and answer a feedback form.
- *Step 3: Variability-Aware Smell Inspection Reports Aggregation Analysis:* in this activity, study researchers make an aggregation analysis in order to verify false positive smell occurrence and new entrance not previously recorded in smell occurrences oracle.

#### **5. Experimental Design**

Each participant should perform variability-aware smell detection in feature model and source code artifacts. Then, the participants will send the variability-aware smell occurrences report and answer the experiment feedback form.

##### **5.1. Factors and Treatments**

##### **Software Development Experience**

For the software development experience factor, we define two treatments: Expert developers and Novice developers.

## Programming Language Experience

For the programming language experience factor, we define three treatments: Expert Java developers, Novice Java developers and Other programming language developers.

## 6. SPL Open Source Projects

Two SPL projects composed the set of study object in that experiment and they are distributed in two application domains (i.e., e-commerce and instant messenger). Table 1 summarizes the projects to be reviewed and inspected in the experimental study. All projects were implemented with annotation-based approach through `#ifdef` directives in Java language.

Table 1

| Project      | Domain            | #Features | #LOC | #Classes |
|--------------|-------------------|-----------|------|----------|
| SPL WebStore | e-commerce        | 20        | 1733 | 5        |
| SPL Chat     | Instant Messenger | 24        | 1617 | 8        |

## 7. Data Collection

In this experimental study will be collected the following data:

- Participants Background
- Variability-Aware Smell Report
- Variability-Aware Smell detection time
- Participants Opinion on Variability-Aware Smell impact

## 8. Data Analysis

In this experimental study will analysis data in order to:

- Remove False positives.
- Calculate Variability-Aware Smell detection *Precision*, *Effectiveness*, and *Efficiency* per participant.