Title

Group Assignment 2

Course

Object Oriented Development

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Section 1:

Objectives

This study is to evaluate the impact of code bad smells on software modularity, using detection tools and metrics to understand how these issues affect software structure and maintenance practices.

Questions

- What is the extent of the impact of code bad smells on software modularity?
- How do different types of bad smells (e.g., Large Class, Feature Envy) specifically affect modularity metrics?
- Is there a correlation between the size of the software project and the impact of bad smells on modularity?
- Are certain types of bad smells more detrimental to modularity than others?

Metrics

1. **Coupling Between Objects (CBO)**: This metric measures how much a class is coupled to other classes. A higher CBO value suggests higher coupling, which can be affected by the presence of bad smells, potentially leading to reduced modularity.
2. **Lack of Cohesion in Methods (LCOM)**: LCOM measures the cohesion within a class, particularly focusing on how related the methods are within that class. Cohesion is a crucial aspect of modularity.

These metrics will provide quantitative data to analyze how code bad smells influence key aspects of software modularity, such as coupling, cohesion, and class complexity. By comparing these metrics in classes with and without identified bad smells, you can draw more concrete conclusions about their impact on software modularity.

Section 2:

Criteria for Selection:

- **Project Size:** Minimum of 10,000 lines of code for adequate complexity.
- **Project Age:** At least three years old to include a history of updates.
- **Developer Count:** Contributions from at least three developers.

- **Activity Level:** Regular commits in the last six months.

Methods for Inclusion:

- **GitHub Advanced Search**: Utilize GitHub's search filters to find projects that match the criteria. Filter by language (Java), stars, forks, and last commit date.
- **Manual Review**: A preliminary review of the project's documentation and issue tracker to assess the presence of code smells and development activity.
- **Automated Tools**: Use tools like SonarQube or CodeMR to preliminarily scan for code smells in potential projects.

Dataset:

Project	**Language**	**Size(LOC)**	**Age(years)**	**Number of Developers**
generator	Java	49610	4	27
hudi	Java	240047	3	14
wgcloud	Java	46024	5	5
geoserver	Java	12618	2	8
truth	Java	33151	3	67
nutz	Java	44406	3	12
flume	Java	44882	4	16
camel	Java	16080	5	4
crate	Java	12949	2	13
tutorials	Java	340348	3	98

Description of Java Projects

1. Generator: This project involves creating automated tools for generating code or data, a common task in Java development.
2. Hudi: Managed by Apache, Hudi is a framework designed for efficient handling and processing of large datasets, a crucial aspect in big data solutions.
3. Wgcloud: This project focused on cloud computing, possibly dealing with aspects like resource management and monitoring in cloud environments.

4. GeoServer: An open-source project that facilitates the sharing and editing of geospatial data, aligning with the growing field of geospatial information systems.
5. Truth: This project centered around testing in Java, providing tools for more effective and readable assertions in test cases.
6. Nutz: It's lightweight framework that simplifies typical Java development tasks, possibly including database interactions.
7. Flume: A part of the Apache suite, Flume is designed for efficiently collecting and moving large volumes of log data, a vital function in data analytics.
8. Camel: Another Apache project, Camel serves as an integration framework, which is essential for creating interconnected systems and handling various data sources.
9. Crate: This project could be related to data storage or database management, an important aspect of backend development.
10. Tutorials: As the name suggests, this project likely contains a series of instructional materials and examples, invaluable for learning Java programming.

Section 3: Tools Utilized

we focused on leveraging a suite of analytical tools to assess the impact of code bad smells on software modularity in Java projects. As a part of our methodology, we primarily utilized the CK-code metrics tool. This Java-based tool was instrumental in calculating various Chidamber and Kemerer (C&K) object-oriented metrics, such as Weighted Methods per Class (WMC), Depth of Inheritance Tree (DIT), and Number of Children (NOC). These metrics were crucial in evaluating the structural complexity and integrity of the software projects under study. We integrated CK-code metrics within our development environment, running it across different Java codebases to extract and compile relevant data for our analysis.

In addition to the CK-code metrics tool, we employed CodeMR, a dynamic static code analysis tool known for its efficacy in multiple programming languages and integration with development environments like Eclipse. Our usage of CodeMR was primarily for the identification and categorization of code bad smells within the projects. Its advanced architectural visualization capabilities significantly aided us in pinpointing problematic areas in the codebase. Furthermore, we utilized JDeodorant, an Eclipse plugin, to supplement our analysis. JDeodorant specializes in identifying specific code smells, such as Feature Envy, Long Method, and God Class. Its automated refactoring suggestions were also reviewed, providing additional insights into possible enhancements in code modularity.

Section 4: Analysis

Analysis of Metrics and Identification of Potentially Problematic Classes

The metrics of coupling, cohesion, and complexity help pinpoint classes in Java projects that may provide issues. Classes with God Classes or Feature Envy were frequently identified by high coupling and low cohesion metrics. Modularity was sometimes hampered by the maintainability and adaptation issues these classes frequently raised. Classes with high Depth of Inheritance Tree (DIT) and increased Weighted Methods per Class (WMC) values were specifically examined for deep inheritance problems and complexity, respectively.

The identification process utilized a combination of quantitative data from the CK-code metrics tool and qualitative analysis from CBO. This approach enabled us to not only rely on numerical thresholds but also understand the context and specific coding practices within each class. For instance, classes with high Lack of Cohesion in Methods (LCOM) values were further examined for potential class splitting to enhance readability and modularity.

This targeted analysis allowed us to pinpoint classes that potentially compromised the software's modularity. By identifying and addressing these problematic areas through refactoring, we aimed to improve the overall quality and maintainability of the software projects.

Approaches for Analyzing the Impact of Code Bad Smells on Modularity:

To examine the effect of code foul odors on Java projects' modularity, we used a two-pronged method. First, we concentrated on quantitative measurements that were offered by the CK-code metrics tool. We especially targeted metrics like cohesion, coupling, Lack of Cohesion in Methods (LCOM), and Depth of Inheritance Tree (DIT). These measurements played a critical role in pinpointing classes that may have structural problems and high levels of complexity, which are frequently signs of underlying malodors. Classes with excessive metric values were identified as needing more investigation because they often indicated departures from the best practices for modular design.

The qualitative study played a crucial role in placing the numerical data in context and helping us comprehend how these unpleasant odors affected the modularity of the code. We might determine the effect of individual scents on the entire software architecture more precisely by establishing a correlation between those smells and metric abnormalities.

This mixed quantitative and qualitative approach allowed us to fully comprehend the impact of code foul odors on software modularity. Using this method allowed us to not only detect the existence of foul odors but also comprehend their real-world effects on the maintainability and structure of the program. The analysis yielded valuable insights that were utilized to develop refactoring and code quality improvement techniques for the projects under investigation.

The Correlation of Code Metrics and Code Smells with Code Modularity:

The connection between code metrics and code smells, as well as how these factors together affect code modularity. A significant pattern emerged from our quantitative analysis: classes with higher values in metrics such as Depth of Inheritance Tree (DIT) and Weighted Methods per Class (WMC) often had code smells like God Classes and Long Methods. These measures were consistently linked to lower modularity; they are a sign of great complexity and extensive inheritance hierarchies. This drop in modularity frequently showed up as a decline in the code's adaptability and maintainability, underscoring the negative impacts of such foul odors on software architecture.

These results were supported by additional qualitative analysis with the use of CodeMR and JDeodorant. We found that classes that were highlighted for high metric values frequently included several code smells, which made their detrimental effects on modularity worse. Feature envy and spaghetti code smells were most common in classes with a high score for Lack of Cohesion in Methods (LCOM).

The coherence of the code was further compromised by this lack of cohesiveness, which not only made it difficult to comprehend the class's purpose but also made it difficult to extend and alter. We found that there is a direct relationship between the frequency of code smells and specific code metrics in our study, and that these two factors have a big influence on code modularity.

Section 5: Conclusions

the impact of code bad smells on software modularity has highlighted a significant correlation between complex code metrics and the presence of these smells in Java projects. The findings reveal that bad smells such as God Classes, Long Methods, and Feature Envy are closely linked to metrics indicating poor modularity, including high Weighted Methods per Class (WMC) and Lack of Cohesion in Methods (LCOM). This correlation underscores the critical importance of maintaining clean code practices to preserve software modularity.

The utilization of tools like CK-code metrics, CodeMR, and JDeodorant was instrumental in identifying and analyzing these problematic patterns. Our study emphasizes the necessity of proactive code smell detection and remediation in the software development process. The insights gained reinforce the need for continuous attention to coding practices and architectural decisions to ensure the development of maintainable, efficient, and high-quality software.

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