OOD ASSIGNMENT 2

Section 1: Objectives, Questions, and Metrics

Objective: The objective of this empirical study is to investigate the effect of code bad smells on modularity in software projects. We aim to analyse the relationship between the presence of code bad smells and the modularity metrics of coupling and cohesion.

Research Questions:

1. How does the presence of code bad smells impact the modularity of software projects?
2. Are there significant differences in the modularity metrics (coupling and cohesion) between classes with code bad smells and classes without code bad smells?
3. What are the trends observed in the modularity metrics across the studied projects?

Metrics: To assess modularity, the following metrics will be used:

1. Coupling (CBO): This metric quantifies class or module interdependence. Higher coupling levels suggest greater interdependence, which may result in less modularity.

2. Cohesion (LCOM): This metric assesses how closely related and focused pieces inside a module are on a particular duty. Higher cohesiveness values suggest a more robust modular design. These metrics will be obtained using the CK-code metrics tool, as introduced in assignment.

The tool provides quantitative values for coupling and cohesion, enabling us to assess the modularity of the software projects under study.

By analysing the relationship between code bad smells and the modularity metrics, we aim to gain insights into how code quality issues impact the modularity of software projects and identify any significant patterns or trends across the studied projects.

Section 2

Describe the subject programs or what is also called Data set.

For this empirical study, we have selected a set of Java projects from GitHub that meet our criteria for analysis. The chosen projects provide a diverse range of software systems to ensure a comprehensive examination of the effect of code bad smells on modularity.

The table below presents the main attributes of each studied program, including the project name, description, number of lines of code (LOC), number of contributors, and age of the project: issues, and total number of commits.

Program Name	Description	Size	Open Issues	Commits
AndroidAll-master	AndroidAll is a project dedicated to providing a comprehensive collection of Android development resources and tools.	20049	3	411
DataX-master	It is a project that focuses on simplifying data integration and migration processes.	19714	947	350
GeometricWeather-master	Geometric Weather is a project that offers a comprehensive weather forecasting and information retrieval system.	986182	164	431
microservices-platform-master	Microservices-platform is a project that aims to simplify the development and deployment of microservices architectures.	250093	1	477
sofa-ark-master	Sofa-ark is a project that provides a powerful and flexible runtime environment for running Java applications in a modular and isolated manner.	44673	43	258
testing-samples-main	A collection of samples demonstrating different frameworks and techniques for automated testing	11922	434	106
AisenWeiBo	"Sina Weibo third-party Android client" refers to an unofficial app developed by a third-party developer for Android users to access Sina Weibo, a popular social media platform in China.	83037	45	287
Mlkit	The project is a collection of code samples that demonstrate how to use Google's Machine Learning Kit (ML Kit) for mobile app development on Android and iOS platforms. It includes examples for text recognition, face detection, image labeling, object detection, and more.	47428	55	357
Sonic-server	Sonic is a platform that integrates remote control debugging and automated testing of mobile devices and strives to create a better use experience for global developers and test engineers.	88506	12	346
UETool	UETool is a debug tool for anyone who needs to show and edit the attributes of user interface views on mobile devices popup Window or any other view.	17630	2	264

The projects were chosen based on the defined criteria, which included factors such as project size, age, and number of contributors. The size of the projects ensures that there is an adequate amount of code to analyse, while the age and number of contributors provide insights into the development history and maintenance activities performed on the projects.

Each project represents a unique software system, covering various domains and functionalities. Analysing a diverse set of projects allows for a more comprehensive understanding of the impact of code bad smells on modularity in different contexts.

1. **<u>AndroidAll-master:</u>**

   AndroidAll is an open-source project that aims to offer a comprehensive collection of resources and tools for Android development. It serves as a centralized repository, providing Android developers with access to libraries, frameworks, sample projects, and documentation. By utilizing AndroidAll, developers can expedite their Android app development process by easily exploring and utilizing various resources. The project also promotes collaboration and community contribution, making it a valuable platform for knowledge sharing, problem-solving, and staying updated with the latest Android trends and best practices.

2. **<u>DataX-master:</u>**

   DataX is a project focused on simplifying the integration and migration of data. It provides a flexible and scalable framework for efficiently transferring data across different platforms and systems. With DataX, users can easily extract, transform, and load data from diverse sources to their desired destinations, such as databases, data lakes, or cloud storage. The project supports a wide range of data formats and offers extensive configuration options, making it adaptable to different data integration use cases.

3. **<u>GeometricWeather:</u>**

   GeometricWeather is an open-source project that offers a comprehensive system for weather forecasting and information retrieval. It provides developers with a user-friendly API to access weather data from various sources and presents it in an engaging and informative manner. GeometricWeather supports a wide range of weather parameters, including temperature, humidity, wind speed, and precipitation. Additionally, it includes features like weather alerts, sunrise and sunset times, and multi-language support.

4. **<u>Microservices-platform:</u>**

   The Microservices-platform project aims to simplify the development and deployment of applications based on the microservices architecture. It provides a robust and scalable platform equipped with essential tools, frameworks, and guidelines for building microservices-based applications. The project offers features such as service discovery, load balancing, and centralized logging, facilitating seamless communication and management between microservices. It also includes deployment scripts and supports containerization for easy scaling and deployment of microservices.

5. **<u>Sofa-ark:</u>**
   Sofa-ark is a project that offers a flexible and powerful runtime environment for executing Java applications in a modular and isolated manner. It utilizes a plugin-based architecture, allowing developers to easily manage dependencies, classloading, and versioning of application modules. By using Sofa-ark, developers can seamlessly integrate multiple Java applications within a single runtime environment, optimizing resource utilization and improving overall performance. The project supports features like dynamic class reloading, module isolation, and hot plugin deployment.

6. **Testing-samples-main:**

   The "Testing-samples-main" project is an open-source collection of sample code and resources dedicated to software testing. It serves as a valuable repository for developers and testers to explore and learn different testing techniques, frameworks, and tools. The project includes a wide range of sample code snippets, test cases, and testing methodologies that cover various aspects of software testing, including unit testing, integration testing, and performance testing. By studying and experimenting with the code samples and resources provided in "Testing-samples-main," users can gain practical insights into effective testing practices and enhance their testing skills.

7. **Sonic-server**:
   Sonic-server is a backend server designed to complement the Sonic search library. It offers high-speed full-text search functionality for applications, enabling efficient retrieval of relevant information.

8. **UETool:**

   UETool is a library developed specifically for Android app development. It provides a comprehensive set of debugging and UI development tools, including features like layout borders, widget measurement, and view hierarchy inspection. These tools assist developers in identifying and resolving UI-related issues during the development process.

9. **AisenWeiBo:**

   AisenWeiBo is an open-source third-party client for Sina Weibo, a popular social media platform. It offers a range of features such as support for multiple accounts, customizable themes, and an extended timeline display. Developed using Java, AisenWeiBo adheres to the Material Design guidelines for Android, ensuring a visually appealing and user-friendly interface.

10. **mlkit:**

    mlkit, developed by Google, is a collection of machine learning tools specifically designed for mobile app development. It provides on-device APIs that enable developers to incorporate advanced features like text recognition, face detection, image labeling, and more into their applications. These tools empower developers to create powerful and intelligent mobile apps without relying on external servers for processing.

Section 3

Description of the Tool Used

Tool 1: CK-Code Metrics Tool

For our project, we utilized the CK-Code metrics tool, an open-source software designed specifically for analyzing Java programs. This tool, developed collaboratively by a team of 24 Java developers, employs static analysis techniques to calculate various software metrics, including the C&K metrics.

To access the CK-Code metrics tool, we downloaded it from its GitHub repository using the link provided in the ReadMe file. Following the instructions outlined by the authors, we installed the necessary dependencies and ran the tool on the selected Java projects.

With its command-line interface, the CK-Code metrics tool generated comprehensive reports for each class within the analyzed Java projects. These reports included valuable insights into the selected metrics, such as the C&K metrics and the size of each class measured in lines of code (LoC).

Throughout our analysis, the CK-Code metrics tool proved to be user-friendly, providing a smooth and straightforward experience. It consistently delivered accurate and reliable results for the Java projects under examination. Additionally, being an open-source tool, it ensured transparency and reproducibility, which are crucial for conducting rigorous research.

To execute the CK metric analysis on a Java project, we utilized the following command:

```
java -jar ck-x.x.x-SNAPSHOT-jar-with-dependencies.jar <project dir> <use jars:true|false> <max files per partition, 0=automatic selection> <variables and fields metrics? True|False> <output dir> [ignored directories...]
```

Tool 2: PMD (Programming Mistake Detector):

For static code analysis of our Java source code, we employed the PMD tool. PMD is an open-source software that utilizes static analysis techniques to identify common programming problems, including potential bugs, dead code, and inefficient code. It is implemented in Java and supports multiple programming languages, including Java, C/C++, and JavaScript.

We selected PMD for our static code analysis as it is widely used in the software development industry and has a strong reputation for detecting common programming errors and providing guidance on how to address them.

To run PMD analysis on a Java project, the following command can be used:

```
pmd.bat check -d <Project Directory> -f <filetype> -R <ruleset.xml> -r <fileName>
```

Section 4:

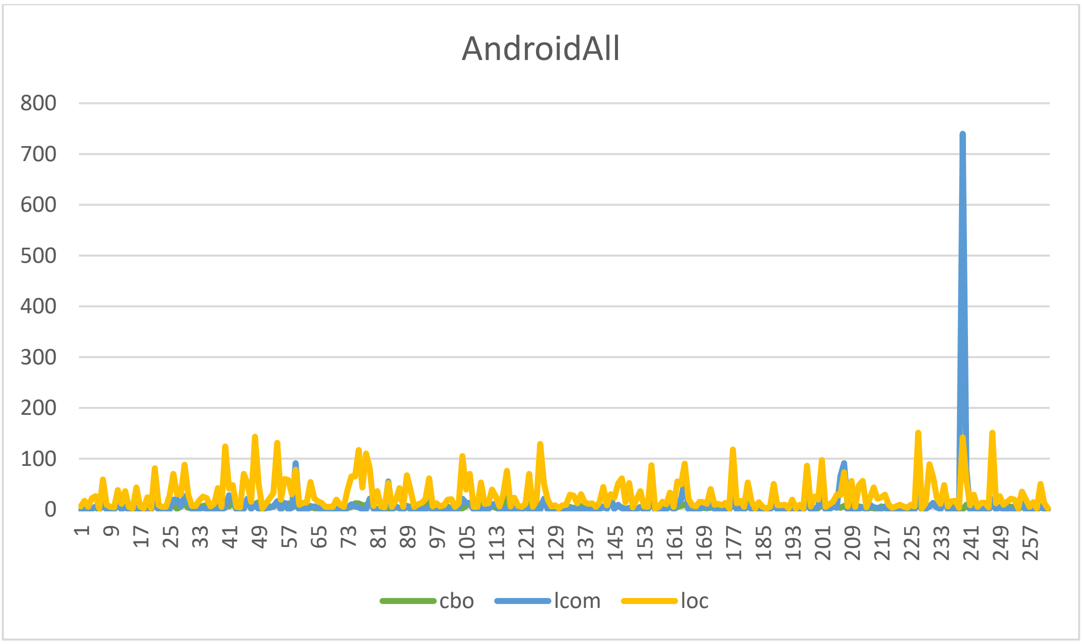
Graphs, Tables and Results

Line Charts for each project:

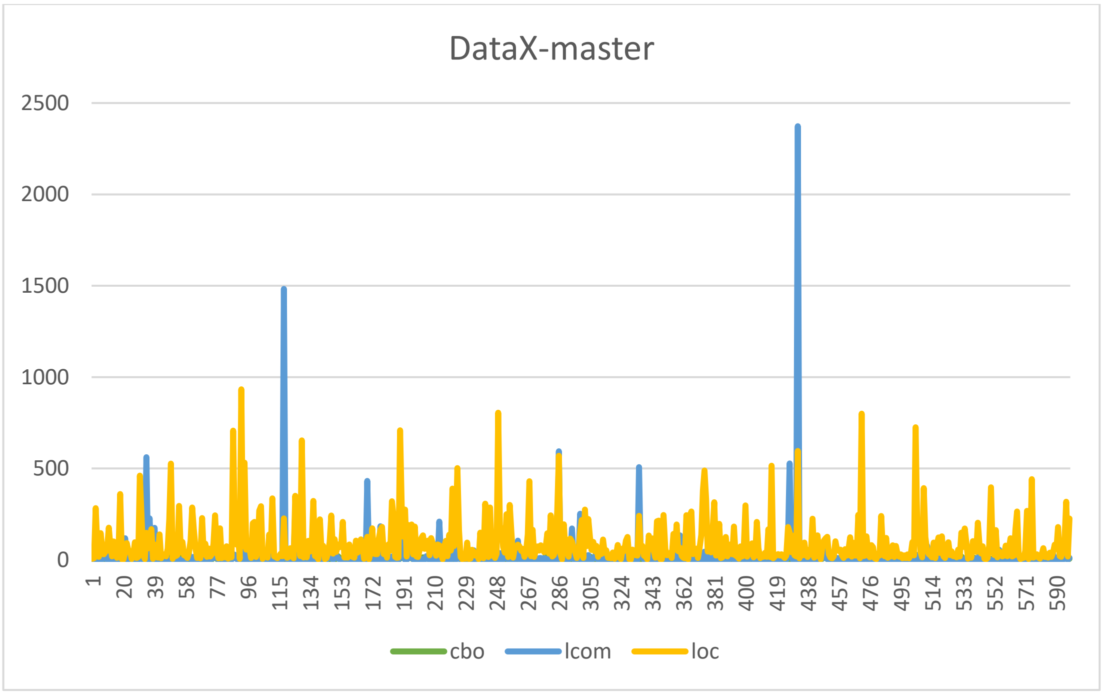
We will describe the findings of our empirical study, which attempted to investigate the relationship between class size and software modularity, in this part. We used the CK-Code metrics tool to calculate certain C&K metrics for a selection of Java projects collected from GitHub to ensure that they satisfied our stated requirements. Our investigation focused on ten projects that fit these criteria, and we used the CK-Code metrics tool to evaluate the classes inside these projects.

We used two C&K metrics to assess modularity: coupling between objects (CBO) and lack of cohesion in methods (LCOM). In addition, we considered class size, as measured by the number of lines of code (LoC), to be an important element in our analysis.

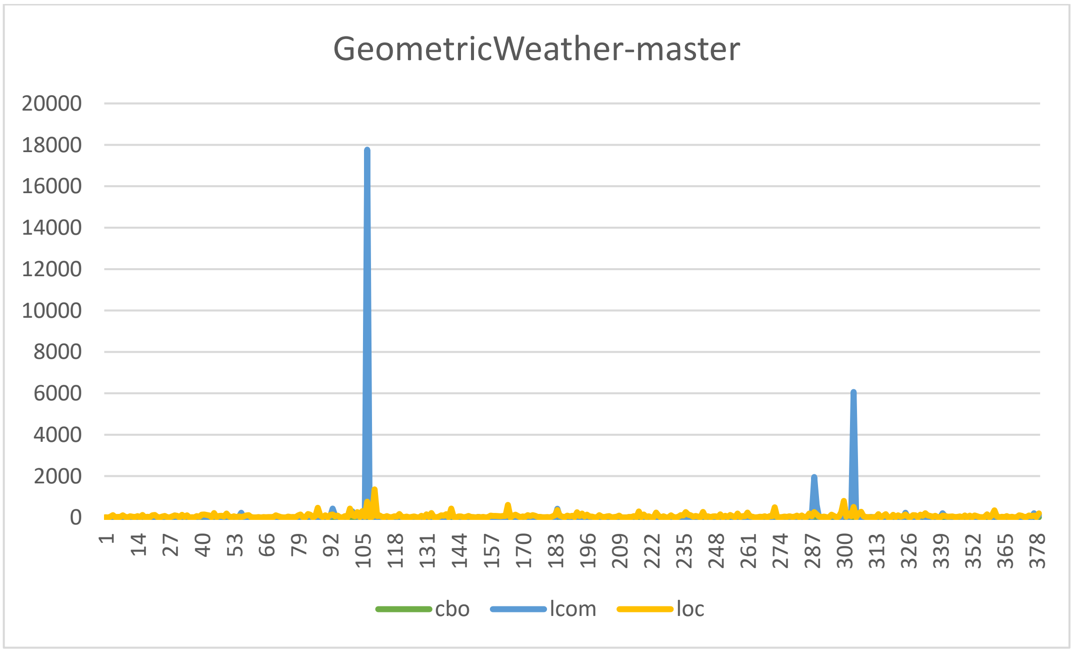
AndroidAll



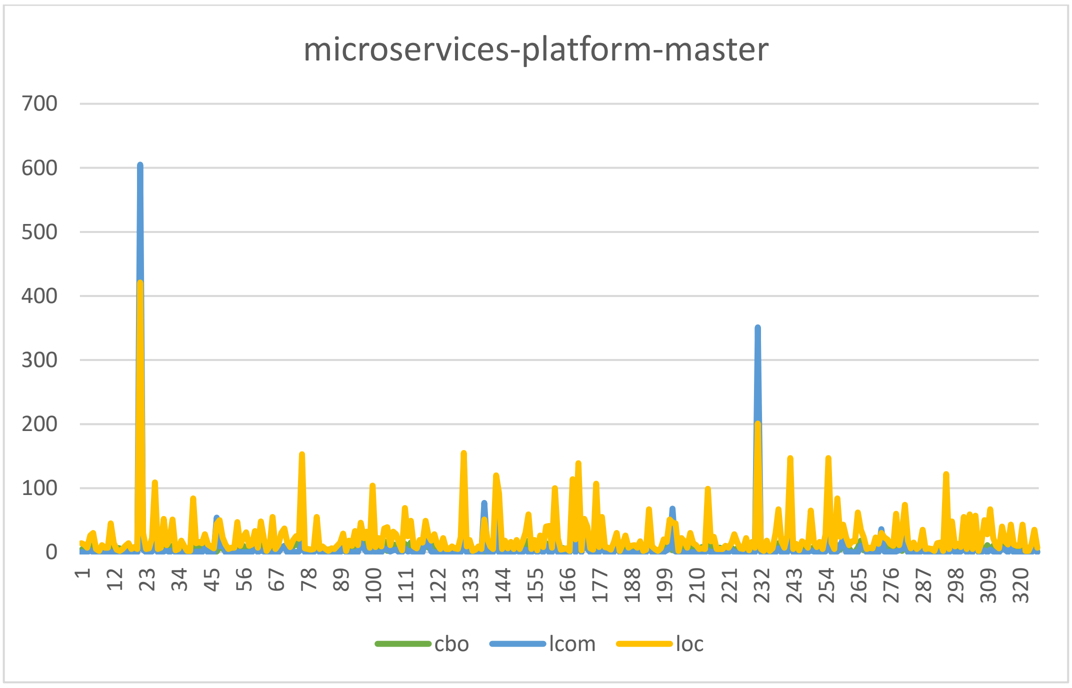
DataX-master:



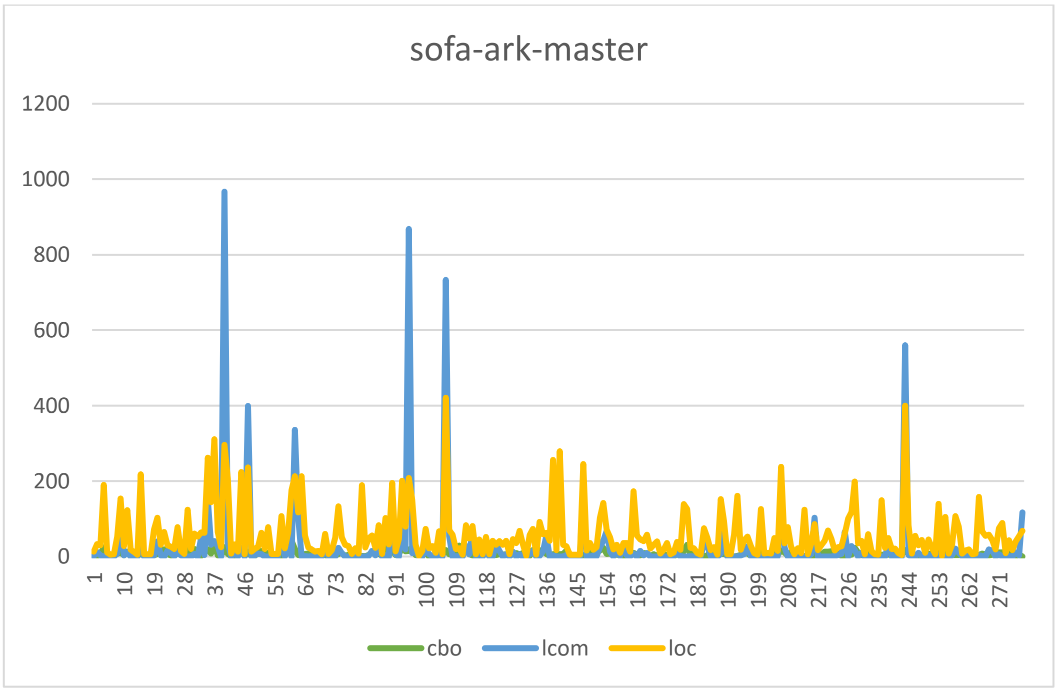
GeometricWeather-master:



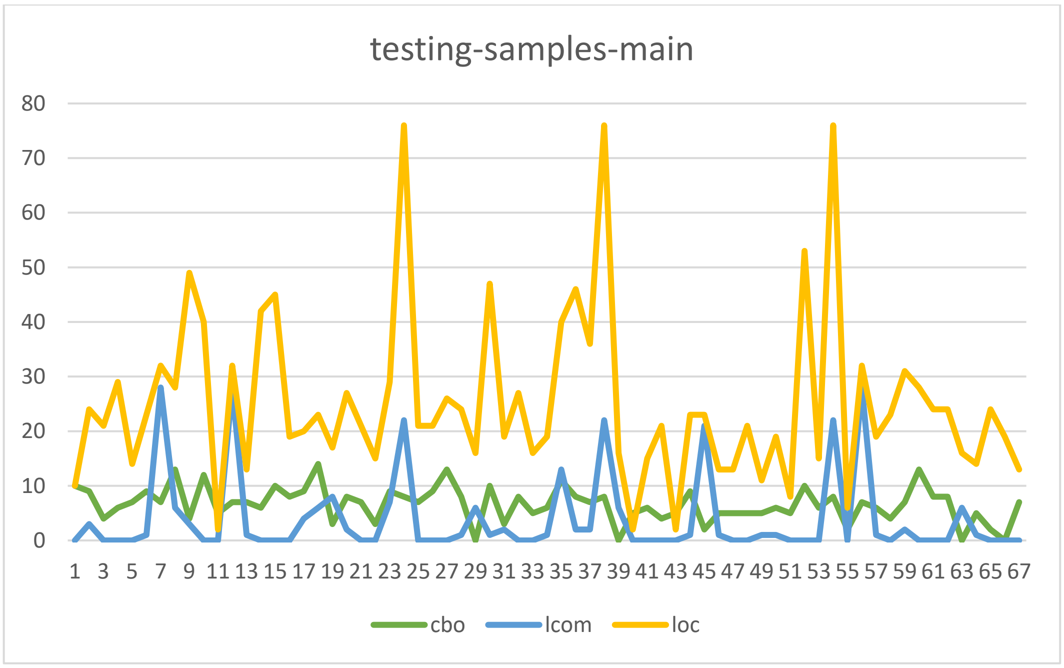
Microservices-platform-master:



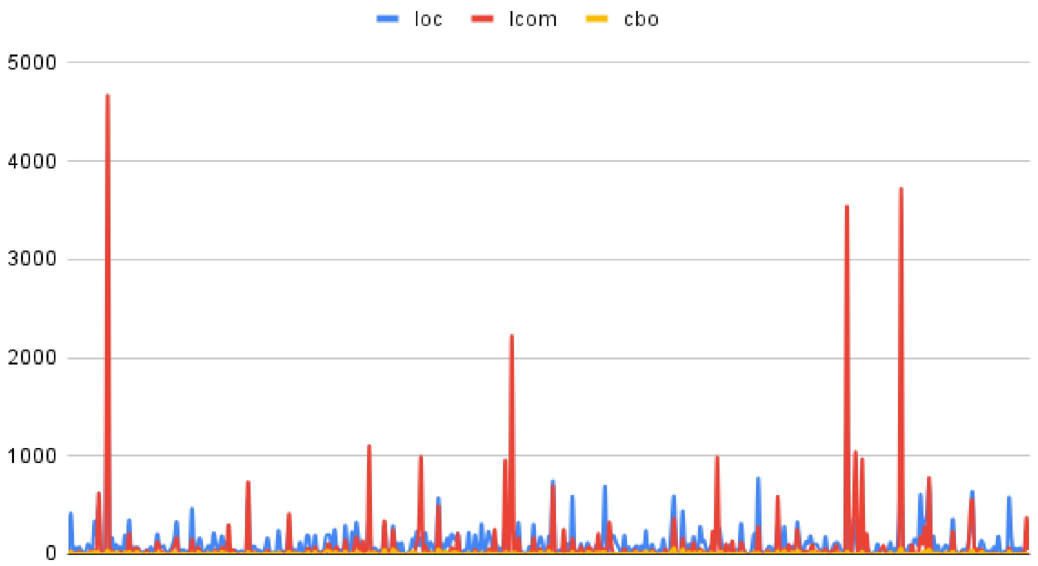
sofa-ark-master:



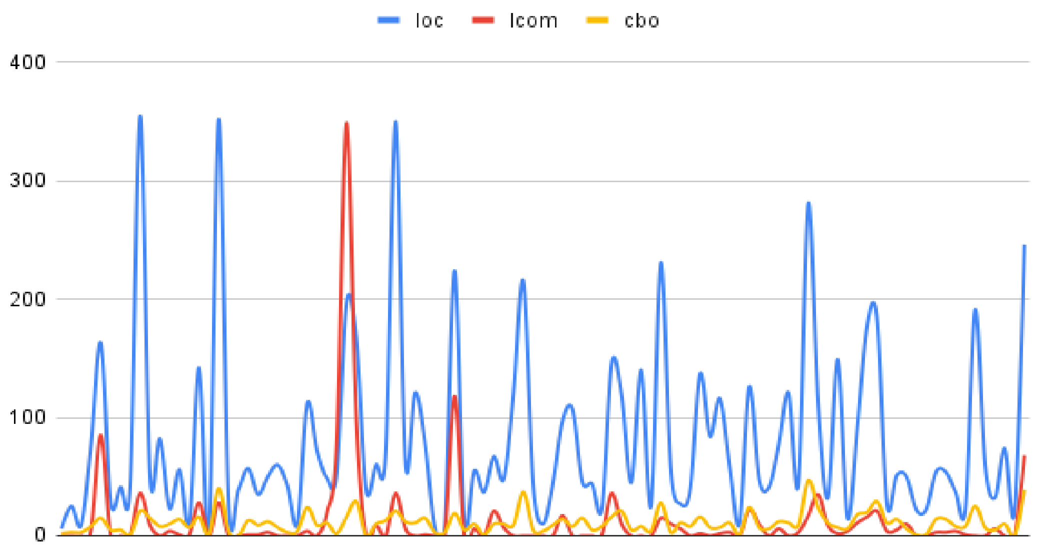
Testing-samples-main:



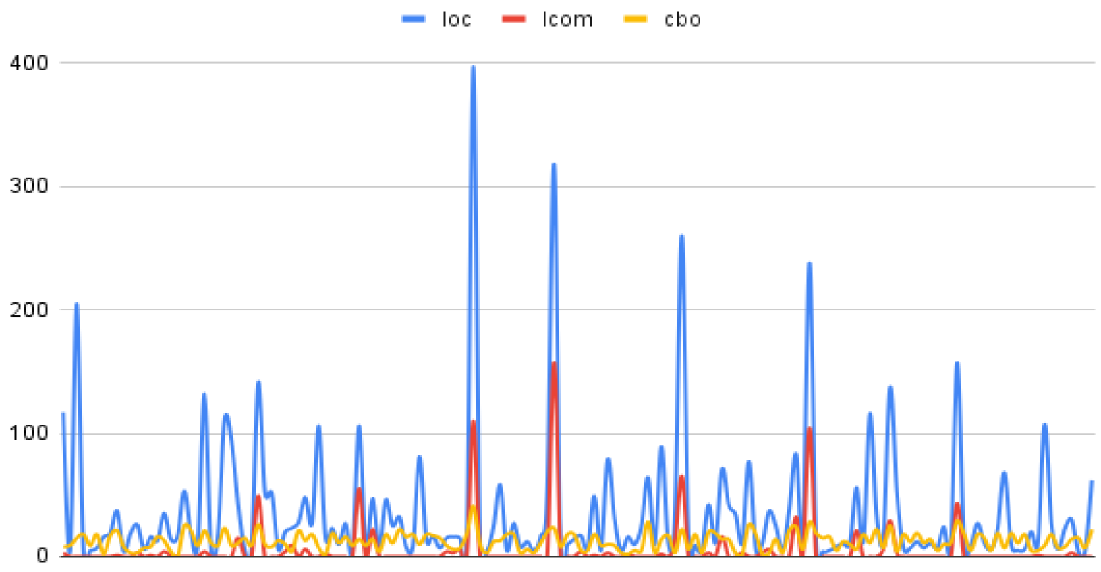
Aisenweibo:



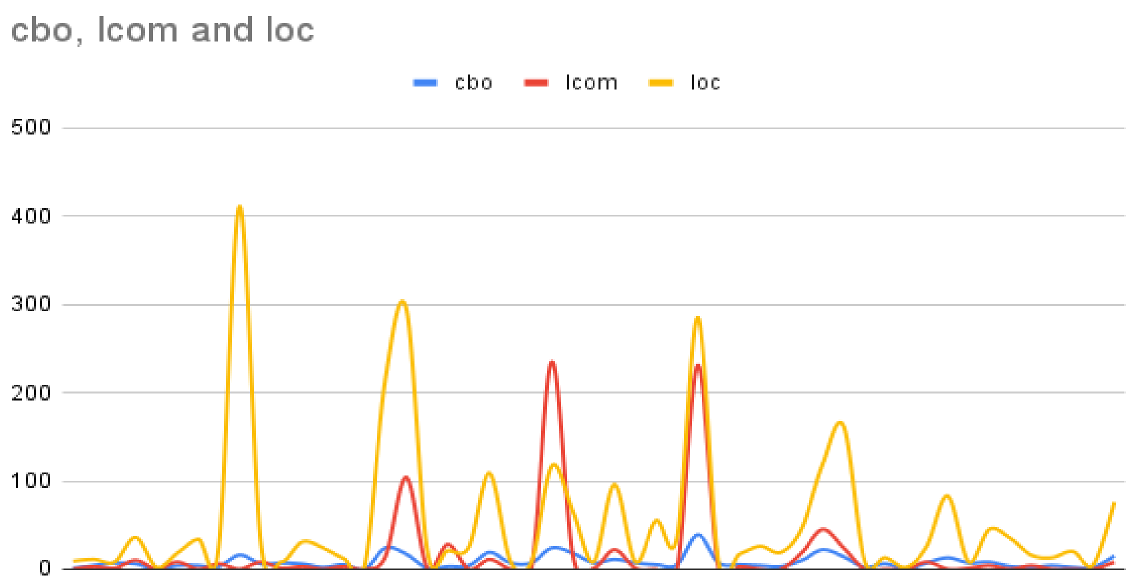
Mlkit:



sonic-server:



UETool:



Result:

To assess the impact of code bad smell on projects, we divide them into two groups: those with and those without. We compute the average values of key metrics like as coupling (CoB) and lack of method cohesion (LCOM) for each group. We may now compare the metrics of the two groups.

We may readily discover any anomalies or patterns in the metric data by graphing the comparison. This graphic representation aids in comprehending the distinctions between the groups. We also include statistical tests to strengthen the study. We can use these tests to see if the observed variations in metric values across groups are statistically significant.

In addition, it is critical to include domain expertise in the research. This entails speaking with professionals who are well-versed in the topic under consideration. Their knowledge and experience contribute to significant insights and interpretations of the data.

Their knowledge and experience help to provide significant insights and interpretations of the data. Based on the investigation, we can deduce that higher metric values in the group with code poor Bad smell may have a negative impact on CoB and LCOM. This inference emphasizes the significance of correcting these code flaws to improve overall code quality.

In summary, the process entails categorizing projects based on the presence or absence of code bad smells, calculating average metric values, comparing metrics via visual charts, incorporating statistical tests for further analysis, and leveraging domain expertise to gain deeper insights. The higher metric values reported in the bad code group suggest a potential negative impact, stressing the importance of addressing these issues for improved code quality.

Project Name	**CBO (Without Bad Smell)**	**LCOM (Without Bad Smell)**	**CBO (With ABad Smell)**	**LCOM (With Bad Smell)**
AndroidAll metrics	3.8	7.9	-	-
microservices-platform-master metrics	7.0	6.4	-	-
sonic-server	12.5	5.3	-	-
testing-samples-main metrics	6.6	3.8	-	-
uetool	7.9	16.1	-	-
aisenweibo	-	-	10.5	89.2
Datax	-	-	4.9	25.1
GeometricWeather-master metrics	-	-	9.8	91.6
mlkit	-	-	11.2	13.3
sofa-ark	-	-	6.7	25.0

Conclusion

Coupling (CBO): Projects without offensive bad smell had an average Coupling (CBO) score of 5.3, which denotes a modest amount of component interdependence. However, in projects with foul bad smell, the average CBO value rises to 8.6, indicating a higher degree of connectivity and stronger interconnections between components. This suggests that projects with foul bad smell have a higher amount of coupling, which may influence the quality of the software.

Lack of Cohesion of Methods (LCOM): In projects without bad smell, the average LCOM rating is 7.3, which denotes a moderate amount of cohesion within classes. On the other hand, in projects with severe bad smell, the average LCOM rating dramatically increases to 48.4, suggesting a serious lack of method cohesiveness. This shows that classes in projects with bad smell have functionality that is dispersed or disconnected, making them harder to maintain and possibly lowering the quality of the software.

Relationship between CBO and LCOM: In both groups, CBO and LCOM show a positive correlation, indicating that as coupling rises, there is a tendency for a greater lack of cohesiveness. The higher average LCOM score suggests that this association may be stronger in projects with unpleasant bad smells. This indicates that the presence of bad smell may make the relationship between coupling and lack of cohesiveness worse, having a more noticeable effect on software quality.

These findings support the hypothesis that the presence of offensive bad smell has a pronounced effect on software quality characteristics like coupling and lack of cohesion. In comparison to projects without foul bad smell, projects with foul bad smell frequently show stronger coupling and a noticeably higher lack of cohesion. These results underline the significance of recognizing and eliminating bad smells to maintain a modular and cohesive codebase, which can eventually improve software quality and maintainability.

References

Fowler, M., Beck, K., & Highsmith, J. (2000). Refactoring: Improving the design of existing code (Addison-Wesley Professional).

Menzies, T. J., & Greenwald, J. (1999). Detecting bad smells in object-oriented software. In Proceedings of the 21st international conference on software engineering (pp. 412-421). IEEE Computer Society.

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