Object Oriented Development

# Overview

In object-oriented Software development, Quality would be determined as a crucial component. To identify the quality of software applications, various measures are used in the landscape. The assessment provides validation of open-source applications using CK metrics and ensures a relationship between class size and maintainability.

# Section 1 - GQM Approach

The Goal Question Metric is a measurement process defining a framework to structure the measures in software engineering. It supports aligning the quality factors by measuring various attributes, architectural patterns, software development design, and other functions of the application. In this quality analysis of software applications, GQM is utilized to establish an objective, determine the questions, and define appropriate metrics to analyze the relationship between the maintainability and size of the project (Choi, son, & Chang, 2020).

***Objective***

The main objective of the assessment is to measure the software application’s quality attributes such as maintainability using various code metrics. With the help of CK code metrics, various attributes of software applications are generated. The attributes support the quality analysis to evaluate the effectiveness of the application. Additionally, class size influence on the maintainability of the application is also identified and evaluated.

**Questions**

* What would be the influence of contractors and distinct methods that influenced the maintainability of class?
* What is the number of classes that are coupled with each class in the application?
* What can be the maximum length of the program path in the primary classes?
* How the complexity of each method in class can be determined?
* How many classes can be derived from the primary class?
* How many non-connected method pairs are available in class without cohesion?

**Metrics**

* Response for class [RFC]
* Coupling Between Objects [CBO]
* Depth of Inheritance Tree [DIT]
* Weighted methods for class [WMC]
* Number of Children [NOC]
* Lack of Cohesion of Methods [LCOM]

# Section 2 - The five Java projects are

|  |  |
| --- | --- |
| **Project** | **Description** |
| Spring Boot | The Spring Boot Java application is a production-grade application powered by Spring. It provides service to software developers and project managers to create spring with absolute and minimum fuss. The application will prioritize the activities and offer an effective and accessible initiation to the spring development. The application is encompassed with Spring Boot which helps developers to create a stand-alone application using Java deployment through Java -JAR or WAR deployment. It can be opinionated to perform configuration and provide a default setting. Moreover, Spring Boot is a Java application development technology for enterprise environments.  Link - <https://github.com/spring-projects/spring-boot> |
| Apollo master | Apollo is an open-source Java application with a reliable configuration management system. The application would centrally manage the configuration operations across various applications and clusters. It would be more suitable for performing configurations with microservice applications.  Link - <https://github.com/apolloconfig/apollo> |
| EasyExcel master | Easy Excel would be one of the Java library applications developed by Alibaba. It offers automatic generation of Excel files during Java application development. the application is mainly developed to address the memory consumption issues in popular frameworks such as Apache POI and ensure an optimized solution with a parsing mechanism for XLSX and XLS formats.  Link - <https://github.com/alibaba/easyexcel> |
| Apache Dubbo | Apache Dubbo is an open-source Java RPC framework with high performance in building enterprise microservice architectures and applications. It could be easier to use because of built-in services discovery, security features, observability, traffic management, and building enterprise-level microservices. The main features described in the application are a transparent interface, intelligent load balancing, automatic service registration, visualized service governance, and runtime traffic routing.  Link - <https://github.com/apache/dubbo> |
| Canal master | The canal would be a waterway or channel application. The tool used to ensure parsing incremental logs for MySQL database. The system enables seamless consumption and subscription of incremental data and its changes over the real-world environment. The core function revolves around the simulation of MySQL replication-based protocol and framework.  Link - <https://github.com/alibaba/canal> |

# Section 3 - CK metrics

The CK metrics tool of statistical analytics tool is used in the assessment to measure the various factors about open-source Java applications. It offers an invaluable indicator of various dimensions of software quality. There are various tools and techniques to measure the software application quality (Tufegdžić & Nedic, 2023). However, CK metrics provide a statistical-based analysis of coding. By executing the open-source program, compilation information about the codes and a large set of measures can be generated for the specific Java application. the metrics such as Response for class, Coupling Between Objects, Depth of Inheritance Tree, Weighted methods for class, Number of Children, Lack of Cohesion of Methods, and so on. The tool mainly measures the aspect of OOPs concept, design complexity, software development architecture, and so on. The code can be improved by the development process using the outlined values from CK metrics. It is also mode helpful to make managerial decisions based on analytical processes (Rebro, Chren, & Rossi, 2023). additionally, issues and challenges regarding the application development can be identified and redesigning of code can be possible by applying CK metrics.

# Section 4 - Graphs and tables

## spring-boot-main – Project

Table 1: Table of CK metrics for Sprint Boot Project

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| class | CBO | wmc | dit | noc | rfc | lcom |
| TestSecurityConfiguration | 4 | 0 | 1 | 0 | 0 | 0 |
| LoadedPemSslStoreTests | 3 | 2 | 1 | 0 | 4 | 1 |
| SortOfInvalidCustomConfiguration | 4 | 0 | 1 | 0 | 0 | 0 |
| Sender | 2 | 1 | 1 | 0 | 1 | 0 |
| CustomFilterPathTests$Application | 7 | 3 | 2 | 0 | 2 | 3 |

Figure 1: Bar chart for spring-boot-main with CK metrics

When considering various metrics and values, LoadedPemSslStoreTests and CustomFilterPathTests$Application classes have stood out with lower CBO, WMC, DIT, RFC, and LCOM values. The class size and code size of the Spring Boot application are minimal. Therefore, the maintainability of the Spring Boot open-source application is easy (Karanikiotis & Symeonidis, 2024).

## easyexcel-master – Project

Table 2: Table of CK metrics for EasyExcel project

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| class | cbo | wmc | dit | noc | rfc | lcom |
| BoundSheetRecordHandler | 4 | 1 | 2 | 0 | 3 | 0 |
| ReadWorkbook | 9 | 0 | 3 | 0 | 0 | 0 |
| LoopMergeStrategy | 4 | 12 | 1 | 0 | 8 | 0 |
| ExcelAnalysisStopException | 1 | 4 | 6 | 0 | 0 | 6 |
| AbstractXlsRecordHandler | 2 | 1 | 1 | 19 | 0 | 0 |

Figure 2: Bar chart for CK metrics of easyexcel-master

The EasyExcel application’s ReadWorkbook package has a higher Coupling Between Objects measure which is 9, which makes the application almost complex. Similarly, Weighted methods for class and RFC are higher for the LoopMergeStrategy package. The AbstractXlsRecordHandler has a higher NOC of around 19, which increases the difficulties of the application to maintain. However, other values are considered to be lower. It determines that the code and class of the application is lower, therefore maintainability of the application also might be not complex (Hu, Jiang, & Hu, 2023).

## dubbo-3.2 – Project

Table 3: Table of CK metrics for the Dubbo project

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| class | cbo | wmc | dit | noc | rfc | lcom |
| InterfaceCompatibleRegistryProtocol | 11 | 6 | 2 | 0 | 11 | 10 |
| Application | 8 | 4 | 1 | 0 | 19 | 3 |
| OneToOneMethodHandler | 7 | 2 | 1 | 0 | 1 | 0 |
| dubbo.Constants | 0 | 0 | 1 | 0 | 0 | 0 |
| ActiveLimitFilter | 11 | 13 | 1 | 0 | 18 | 8 |

Figure 3: CK metrics for the Apache Dubbo project

All the measures obtained for the Apache Dubbo project would be higher and moderated in some classes. It clearly shows that the program is very complex and it has a higher code size. It is complex to identify an error or bug in the complex code. therefore, the Apache Dubbo open-source application’s maintainability is also higher (Choi, son, & Chang, 2020).

## canal-master – Project

Table 4: Table of CK metrics for Canal master project

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| class | cbo | wmc | dit | noc | rfc | lcom |
| TableMapLogEvent$Pair | 0 | 0 | 1 | 0 | 0 | 0 |
| RdbConfigMonitor | 8 | 4 | 2 | 0 | 10 | 0 |
| EventTransactionBufferTest | 8 | 16 | 1 | 0 | 33 | 4 |
| RdsBinlogOpenApi | 9 | 16 | 1 | 0 | 21 | 0 |
| MetaLogPositionManagerTest | 15 | 4 | 3 | 0 | 17 | 0 |

Figure 4: CK metrics and measures for the Canal Master project

The overall values across the various measures could be considered as higher and it remains the project has more classes and methods to process the application functionality. Additionally, a feature of the application is higher that remines the complex code that has been used in the project. The higher CBO, WMC, DIT, and RFC are describing the application maintainability as complex (Rebro, Chren, & Rossi, 2023).

## apollo-master – Project

Table 5: Table of CK metrics for the Apollo Master project

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| class | cbo | wmc | dit | noc | rfc | lcom |
| ServerConfigControllerTest | 4 | 2 | 2 | 0 | 9 | 1 |
| CommitService | 5 | 3 | 1 | 0 | 3 | 0 |
| ApolloAuditScopeManagerTest | 7 | 1 | 1 | 0 | 7 | 0 |
| PageSettingController | 4 | 2 | 1 | 0 | 4 | 0 |
| ConsumerAuthenticationFilter | 9 | 5 | 1 | 0 | 6 | 4 |

Figure 5: CK metrics and measures for the Apollo Master project

In the Apollo Master project, DIT, WMC, and LCOM values are determined to be very low. Also, NOC in all the classes is 0. The limitation in classes and codes are remaining their effectiveness and it determined as easy to use. Therefore, the maintainability of the application is lower.

# Section 5 – Conclusion

The quality analysis report provides the importance of validating the software applications and the significance of software quality metrics. To identify and measure the effectiveness of software quality attributes, five open-source Java applications are validated using CK metrics. One of the effective project objective-defining techniques of the Goal Question metrics approach is applied to determine the assessment objective. It described the main objective to validate the open-source applications using CK metrics and questions with measures to perform the validation operation. From the given link, five effective open-source Java projects and applications are downloaded and extracted. Each project has specific features and functionalities with multiple classes and objectives.

The projects selected for performing validation are Spring Boot, easyexcel Master, apache Dubbo, canal master, and apollo master. These applications are mainly developed by Java programming with object-oriented concepts. It includes various classes, methods, functions, and attributes in a single package. To measure the project code and OOPs concept, CK metrics can be more suitable, which ensures various measures and attributes to validate the project. Using the evaluation of the measures can be possible effectively. It easily extracts the program and determines the code complexity with classes and methods.

In this assessment, the major factors of quality such as code maintainability have been concentrated. When considering the quality of the application, maintainability is more important, which helps to handle and manage the application effectively. This maintainability of the code can be easily influenced by the line of code and its complex classes. Therefore, the measures such as Response for class, Coupling Between Objects, Depth of Inheritance Tree, Weighted methods for class, Number of Children, and Lack of Cohesion of Methods are focused on the projects. From each project, these listed measures are obtained and values are evaluated. Additionally, a graphical representation of each measure for the projects is created using a Bar chart for easy understanding.

From the analysis of measures, the applications such as Spring Boot, EasyExcel Master, and apollo master are lower. Compared to other applications, obtained values such as CBO, WMC, DIT, and RFC are higher in the Apache Dubbo and canal master. Therefore, the maintainability of Apache Dubbo and the canal master would be complex. This validation could be more useful to understand the complexity and make further improvements to applications.

# References

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