Open Source Code Coverage Tools for Java: A Comparative Analysis

Priyanka Dhareula* and Anita Ganpati

Computer Science Department, Himachal Pradesh University, Shimla – 171005, Himachal Pradesh, India; priyankarana.id@gmail.com, anitaganpati@gmail.com

Abstract

This research compares two code coverage tools to understand the relationship between the code coverage and regression testing, henceforth the effectiveness of the code coverage detail provided by the tools. The methodology adopted to meet the objectives follows theoretical as well as empirical approach. To achieve the empirical approach a platform was setup in eclipse IDE for Java application which was integrated with Junit to execute test cases for Java program. Two open source code coverage tools CodeCover and EclEmma were exercised respectively upon a small Java application with twenty one test cases. This execution shows that EclEmma is effective in providing the detail of individual test case. CodeCover on the other side provides combined measurement of the test cases. CodeCover provide the coverage at fine level as well as at coarser level of granularity. However regression testing demands detail coverage made by each test case which code cover fails to dispense. EclEmma generates code coverage report by providing information about individual test case. This information is most desirable when performing test case optimization in regression testing. Further coverage details of test suites given by code coverage tool will be used in proposing a hybrid regression test case optimization technique.

Keywords: CodeCover, Coverage, EclEmma, Regression Testing, Test Case

1. Introduction

The process of testing modifications made to computer programs to make sure that previous code still works with new modifications known as regression testing\(^1\). The quality of software code can be measured and assessed by making use of code coverage analysis for the code. Code coverage defines the measure of code executed during testing. Code coverage is useful during the regression testing, as it helps in identifying the non-covered area and augmenting appropriate test cases to increase the code coverage\(^1\). SUT with high code coverage signifies that it has been thoroughly tested and has a lower chance of containing software bugs than a program with low code coverage.

There are a large number of open source tools available to determine the extent of code coverage provided by test cases for Java based application. For the process of selecting appropriate code coverage tool a comparative analysis of EclEmma and Codecover is performed on a Java based application. These tools are in corporated in Eclipse IDE, where the test cases for both the tools are executed by Junit plug in for Eclipse IDE.

Code coverage analysis targets various aspects of the code, used for different purposes. The main purpose of selecting suitable code coverage tool in this study is to use the details of code coverage for SUT in regression test case optimization. Code coverage inspects the parts of code being exercise by the test cases and that needs to be improved. Code coverage identifies that part of code which has not been exercised by test cases and hence there is a need to augment the test suite. If the test cases are targeting same part of the code, it tells which test cases are redundant\(^2\). The code coverage information can aid in numerous activities viz. regression testing, test case selection, test case prioritization, test case minimization, etc\(^3\). Among various code coverage tools for Java\(^4\), this paper has selected two open source tools for code coverage analysis to evaluate the effectiveness of test cases.

*Author for correspondence
2. Review of Literature

In their research described CodeCover code coverage tool. This paper performed a detailed investigation of ver-
satilities of CodeCover tool for java projects. CodeCover
tool executes on source code by providing synchronized,
term, loop, branch and statement coverage. Code Cover is
open source. The paper discussed that CodeCover can aid
in test case reduction, augmentation of test cases, test case
optimization in regression testing.

Java-based test coverage reporting tool called Java
CodeCoverage. This tool provides test coverage details
for individual as well as test suite as a whole. This tool
is a byte code analyser. A noteworthy character of Java
CodeCoverage is that it stores coverage detail for separate
test cases, hence allowing analysis of detail coverage

An approach for evaluating the features of various test-
ing tools in order to compare them systematically and select
the best one. For the tool comparison they selected two
code coverage tools Emma and CodeCover. The features
selected by them to compare the two tools are Response
Time (RT), Human-Interface Design (HID), Reporting
Features (RF) and Ease of Use (EU). Their analysis con-
cluded that CodeCover tool is more efficient than the
reviewed various code coverage tools and presented the
usage of information obtained by code coverage analysis.

In discovered thirty one tools for code coverage. They
found four tools that aid in branch coverage. They further
chose one tool instrumenting byte code and two tools
instrumenting the source code. From their study they found
that each tool details the branch coverage differently.

In performed experiments in controlled environment
to measure the difference between the details of code cov-
erage provided by various tools. This research used line,
statement, branch and method coverage metrics. Their
results showed that different code coverage tools give dif-
ferent results for mainly branch and method metrics.

An exploratory study of regression test case selection
techniques. There study found that selection of test cases
is primarily focused on the coverage of test case followed
by change identification capability and test case fault
detection.

3. Objectives

The main objective of this research is to compare the code
coverage tools for Java program. However, the specific
objectives of the study are:

- To have an understanding of the relationship between
  the code coverage and regression testing.
- To find the coverage level of granularity (fine granularity
  or coarse granularity) of test cases by CodeCover
  and EclEmma.
- To analyse the effectiveness of the code coverage tools
  on the basis of code coverage information and execu-
tion time taken for code coverage.

4. Research Methodology

To achieve the objectives of the study theoretical as well as
empirical approach has been adopted. In the theoretical
approach many research papers, books, online website were
referred to get a thorough understanding of code coverage
tools used for java and the environment setup required to
perform the analysis. For the empirical approach, a plat-
form was setup in Eclipse IDE for Java developers which
were integrated with Junit to execute test cases for Java
program. Small Java application was used as shown in
Table 1. The details of classes, functions, statements and
the number of test cases used are given in Table 1.

- Person class contains person’s name and maximum
  number of books that this person borrows at a
  particular time.
- Book Class contains title, author and person who
  borrow the book.
- MyLibrary contains list of books and list of people
  who borrows them.

CodeCover and EclEmma were integrated into eclipse
and exercised upon the SUT one after the other to get the
code coverage. The results and comparative analysis for
both the tools is discussed in the next section.

5. Results and Analysis

Firstly, CodeCover was activated for Java SUT. Once
the execution of the application is finished, the cover-
age details are displayed in Coverage view as shown in Figure 1.

The coverage view of CodeCover displays the coverage measurement of the active test cases as shown in Figure 1. In the coverage view each row displays the coverage measurement of the corresponding element. Elements are java classes, functions and the statements of the classes.

Figure 2 displays the snapshot of execution time reported by CodeCover in running twenty one test cases. These test cases took 0.021 seconds to exercise upon SUT.

Secondly, EclEmma was enabled for SUT to get the code coverage of twenty one test cases. Initially only one test case was exercised on SUT to examine its area of coverage. Figure 3 displays the coverage detail of one of the test case named testBook(). Figure 3 shows that testBook() test case gives 2.1% coverage to the SUT. But the big question is what part of SUT is covered by testBook() test case. Figure 3 displays that there are nine instructions in the Book(String) function and the test case testBook() covers all the nine instructions, hence giving 100% coverage to the function Book(String).

It is evident from the snapshot of Figure 3 that EclEmma is an effective tool in determining the coverage at finer level of granularity. To determine whether EclEmma gives the coverage details at coarser level, again we refer to Figure 3 under the src folder the Book class shows 15.3% coverage by the testBook() test case. Therefore, it is evident that out of three classes this test case covered only Book class with 15.3% coverage. Book class contains seven functions out of which testBook() covered only one function Book(String) giving it 100% coverage. Therefore, from these details we can state that EclEmma proves to be efficient tool in providing the details of individual test cases at coarser and finer level of granularity.

Figure 4 shows testBook() test case took 0.008 seconds to exercise on SUT given by EclEmma.

![Figure 1. Coverage view of Codecover for twenty one test cases.](image1.png)

![Figure 2. Snapshot of the time required for running twenty one test cases in Codecover.](image2.png)

![Figure 3. EclEmma coverage report of testBook() test case for SUT](image3.png)

![Figure 4. Snapshot of the time required for running testBook() test cases in EclEmma.](image4.png)
Figure 5 shows the screen shot of all the test cases run in EclEmma. Total twenty one test cases were executed on SUT. The percentage of code coverage detail provided by EclEmma for SUT is 63.4%. This information shows that we need to augment our test suite to maximize the coverage, which will result in better quality software.

Figure 6 shows that it took 0.019 seconds to run twenty one test cases reported by EclEmma. Whereas in case of CodeCover twenty one test cases gave code coverage of 88.7% at statement level in 0.021 seconds.

The graph in Figure 7 shows difference of code coverage between CodeCover and EclEmma. CodeCover give 88.7% coverage in comparison to EclEmma, which gives only 63.4% code coverage. EclEmma is effective for this study as it provides the details of individual test case. In CodeCover the combined measurement of the test cases is given. It is not identifiable as to which test case covered which part of the code. Though CodeCover gives the coverage at fine level of granularity as well as at coarse level of granularity. But regression testing demands the individual detail coverage made by each test case which CodeCover fails to deliberate. EclEmma generates code coverage reports by providing information about individual test case. This information is most desirable when performing test case optimization in regression testing.

It is evident from graph in Figure 8 that CodeCover exercised twenty one test cases in 0.021 seconds in comparison to EclEmma with 0.019 seconds. Therefore, it is stated that EclEmma is most desirable for this study as it executes the test suite in lesser time as compared to CodeCover code coverage tool.

6. Conclusion And Future Work

The quality of SUT can be determined by the extent to which it has been tested. Regression testing can be effective if the designed test cases provide maximum code coverage to SUT. It is impossible to do exhaustive testing but those test cases can be chosen that provide...
maximum code coverage. Therefore, the effectiveness of the test case can be determined by the level of code coverage for SUT. It is evident from the above results that EclEmma is an effective tool in comparison to CodeCover as it can give the details of individual test cases which is required for the optimization of test cases in regression testing. In CodeCover the combined measurement of the test cases is available which does not solve the purpose of examining the coverage of individual test case. Therefore, CodeCover does not aid in determining the effectiveness of individual test case. This further will not aid in regression test cases optimization. For the future work more number of coverage tools with more number of applications will be analysed to get the coverage detail which in turn will help in the regression test case optimization. The coverage details acquired for the test suite by the code coverage tool will be used in proposing a hybrid regression test case optimization technique.

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