

# Interactive Coverage Effectiveness Multiplots for Evaluating Prioritized Regression Test Suites

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## SOFTWARE TESTING CHALLENGES

- ▶ **Complex** source code, databases, files, and network communication
- ▶ Defects may exist in the individual **components** or their **interactions**
- ▶ Testing **isolates defects** and establishes **confidence** in the correctness of software

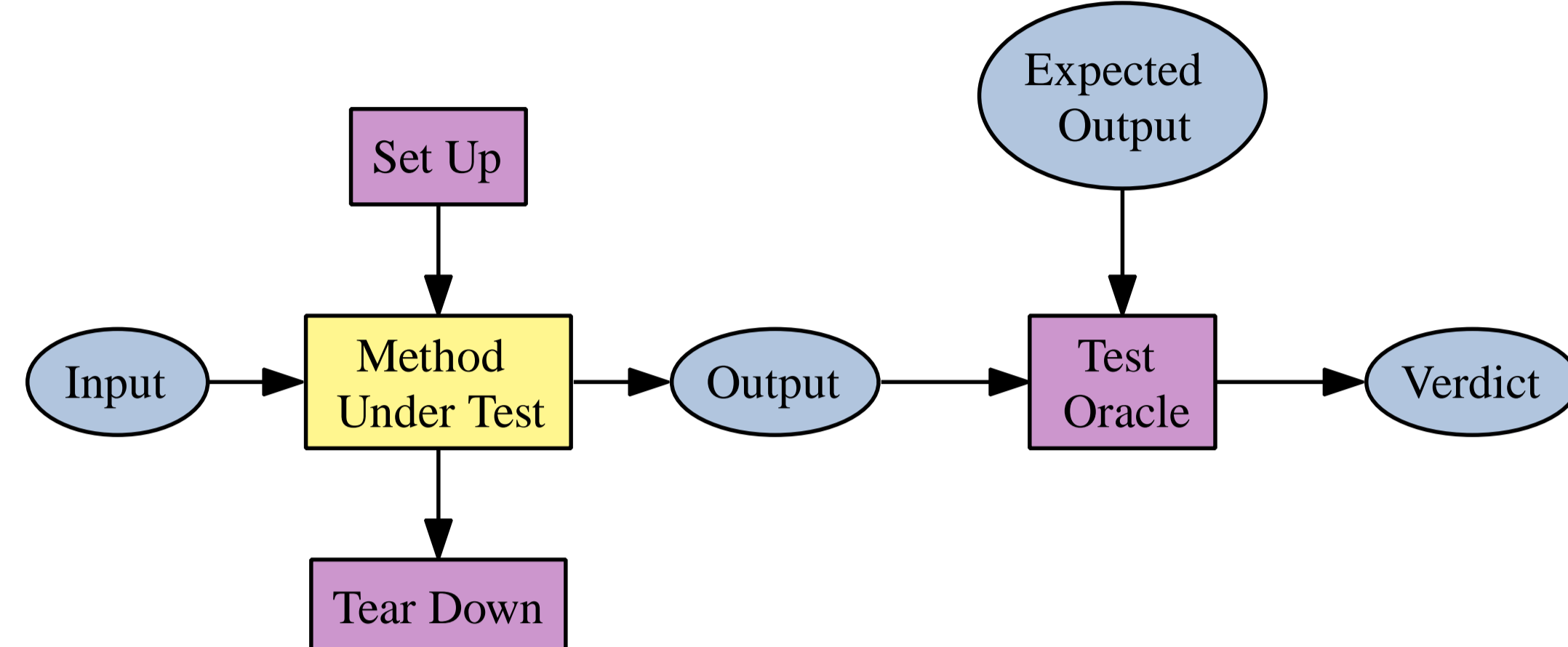


Figure 1: What is a test case? Each test case invokes a method within the program and compares the actual and expected output values.

- ▶ A sequence of test cases is a **test suite**
- ▶ A test suite **executor** such as JUnit runs each test case **independently**

## REGRESSION TESTING

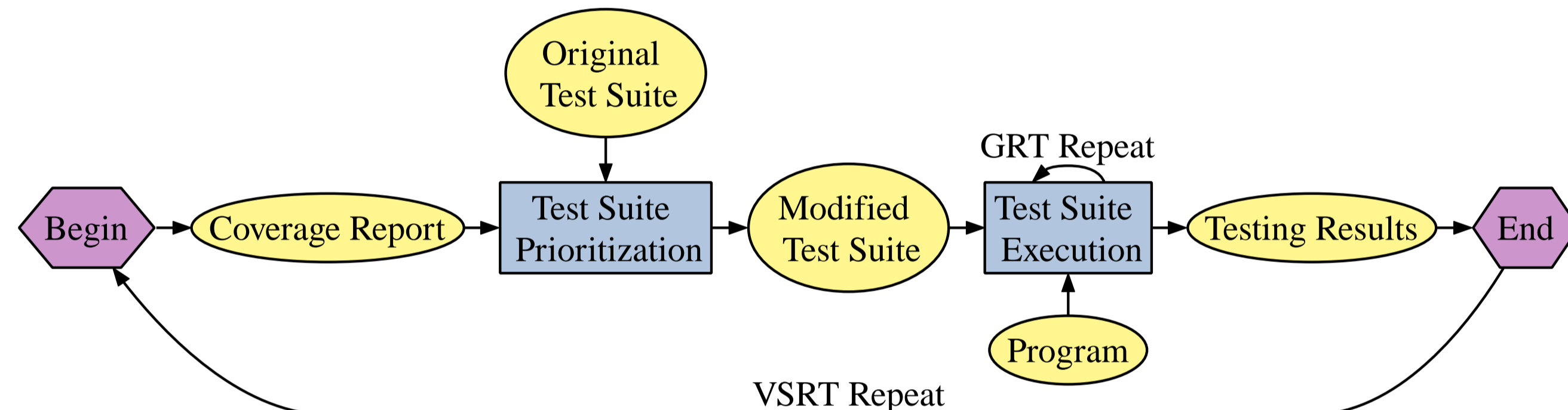
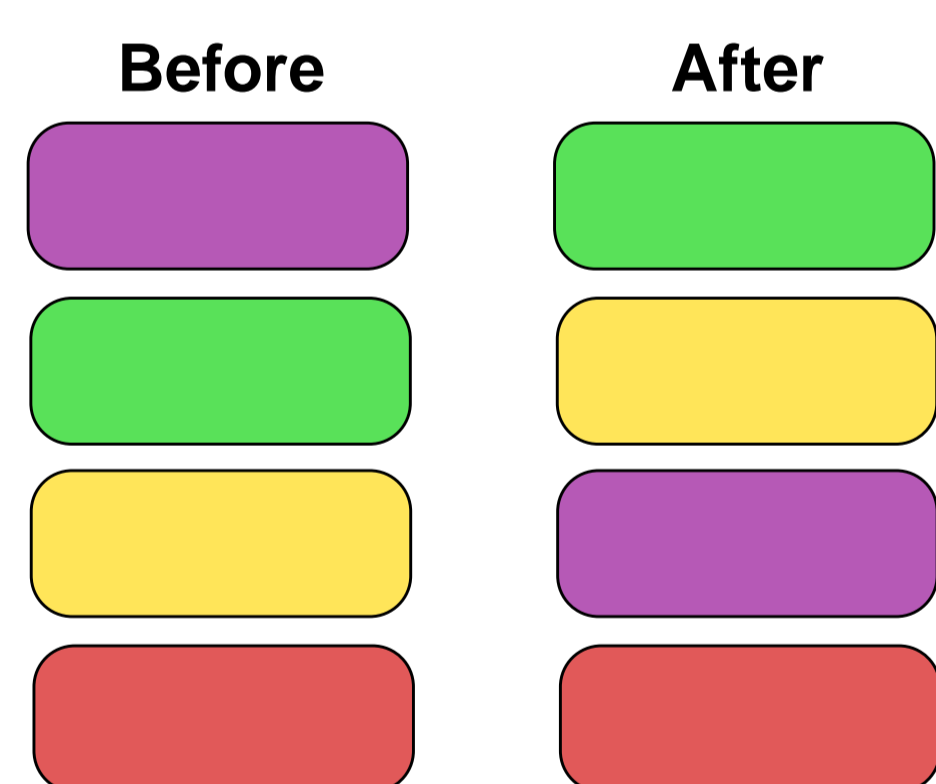


Figure 2: Regression testing. A test suite will be executed repeatedly throughout development, searching for faults introduced by changes made to the software.



- ▶ When software is **modified**, new tests run in addition to the old, increasing the test suite size
- ▶ Execution time of a test suite may be **prohibitive**
- ▶ **Prioritization** techniques **re-order** the tests to locate defects earlier in the test execution process [6, 7]
- ▶ **Coverage reports** identify points in the source code executed, or **covered**, by each test case
- ▶ Prioritizers must analyze the **requirements** covered by each test case to effectively re-order the test suite

## EVALUATING TEST SUITES

- ▶ **Coverage Effectiveness (CE)** rates test suites by how quickly they cover each requirement [4]
- ▶ Prioritize to **increase** the CE of a test suite where  $CE = \frac{\text{Actual}}{\text{Ideal}} \in [0, 1]$

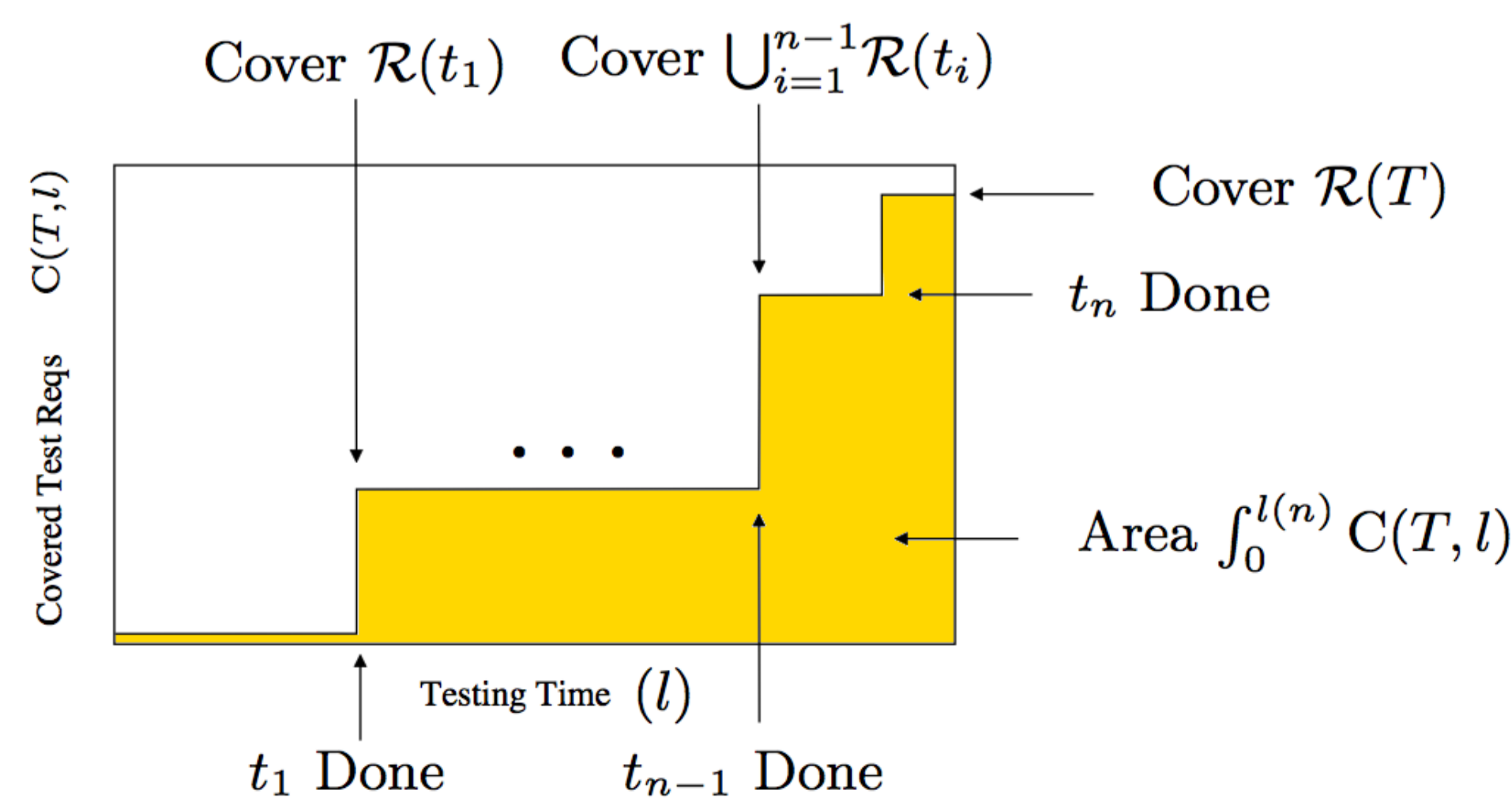


Figure 3: Calculating Coverage Effectiveness (CE). The CE score is the area under  $C(T, l)$  divided by the area under the ideal test suite function (dashed line). Cover  $\mathcal{R}(t)$  denotes the set of requirements covered by test  $t$

## LIMITATIONS FOR TESTERS

- ▶ Many **prioritization** methods exist because finding the **highest CE** by evaluating **all** orderings of a test suite is too **expensive**
- ▶ **Each** of these prioritization techniques can have **many configurations** from which to choose
- ▶ Testers relying on **static** coverage effectiveness multiplots, such as Figure 4, and/or **large tables** of CE scores and test orders can be easily **overwhelmed**
- ▶ **Existing** visualizations assist during **different** development processes such as manual debugging and automated fault localization [2, 3, 5]

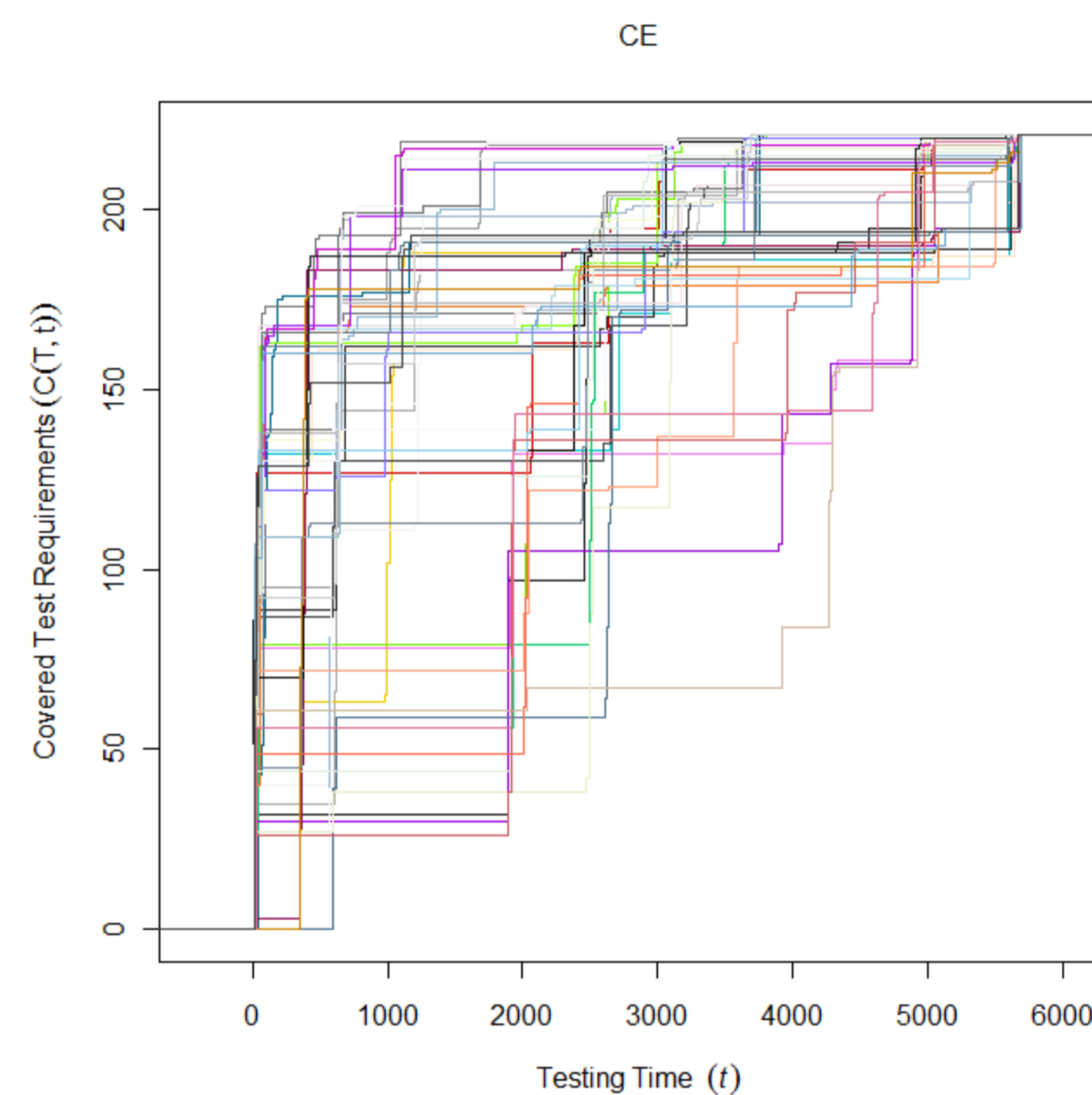


Figure 4: Static Coverage Effectiveness Multiplot. Multiple lines severely clutter the visualization making evaluation and comparison of prioritized test suites nearly impossible.

## VISUALIZATION DESIGN GOALS

- ▶ Enable software testers to **quickly** find the **best** test suite order for their own applications
- ▶ **Interactively** pick prioritizers, comparing CE values and the actual ordering of the tests
- ▶ Utilize prioritization techniques such as **greedy** (GRD), **2-optimal greedy** (2OPT), **delayed greedy** (DGR), and **Harrold Gupta Soffa** (HGS) which use greedy choice metrics (GCMs) to efficiently construct new test orders [7]

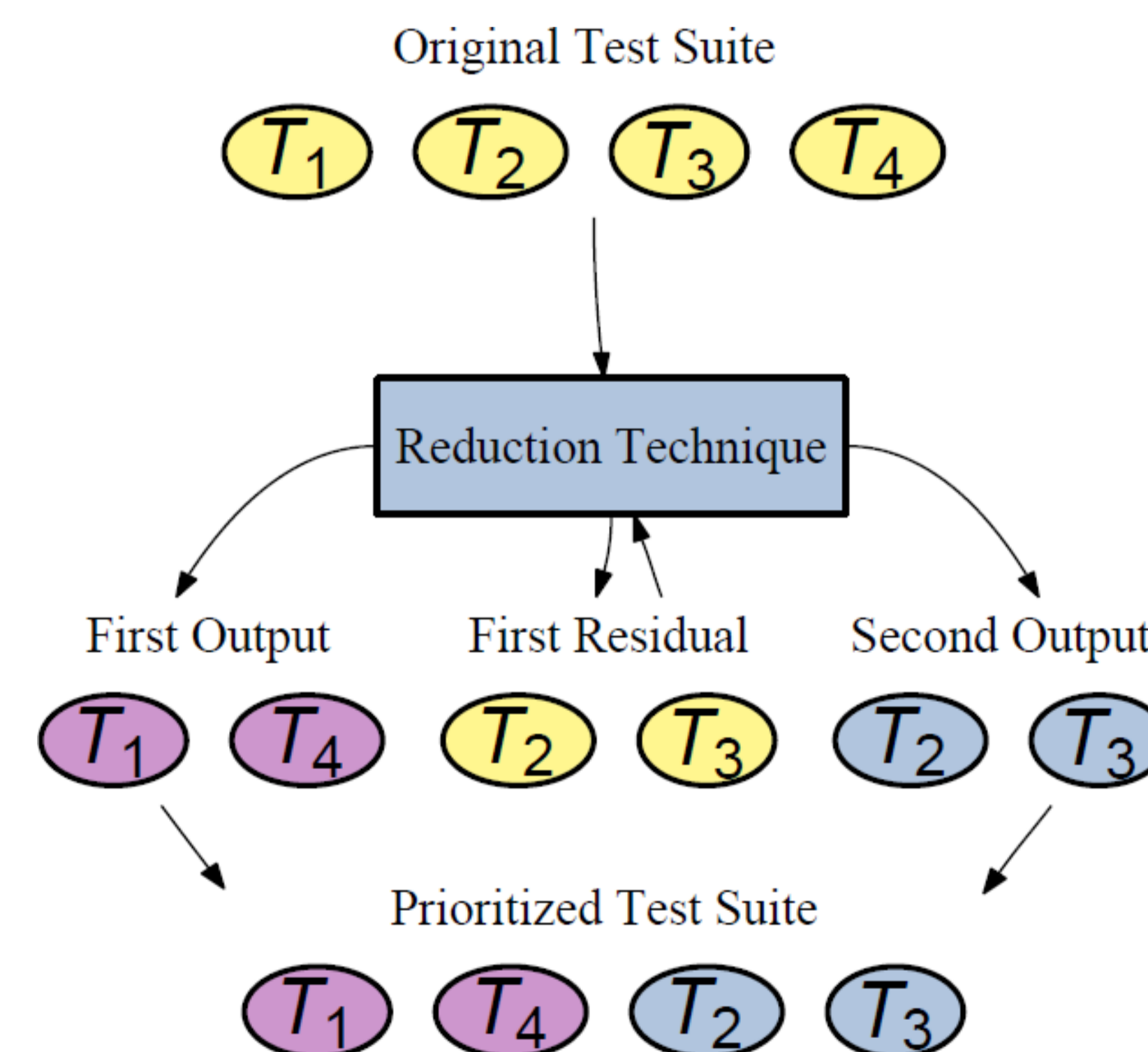


Figure 5: Greedy approaches to test prioritization. Re-order the test suite by repeatedly performing reduction.

- ▶ Make use of the potential power of **reverse** and **random** prioritizations [7]
- ▶ **Visualization** and **UI features** demonstrated by Becker et al. [1] and a NY Times interactive visualization of market statistics (<http://www.nytimes.com/interactive/2008/10/11/business/20081011BEARMARKETS.html>)
- ▶ Encourage **empirical study** on the use of **visualization** during test suite prioritization

## VISUALIZATION FEATURES

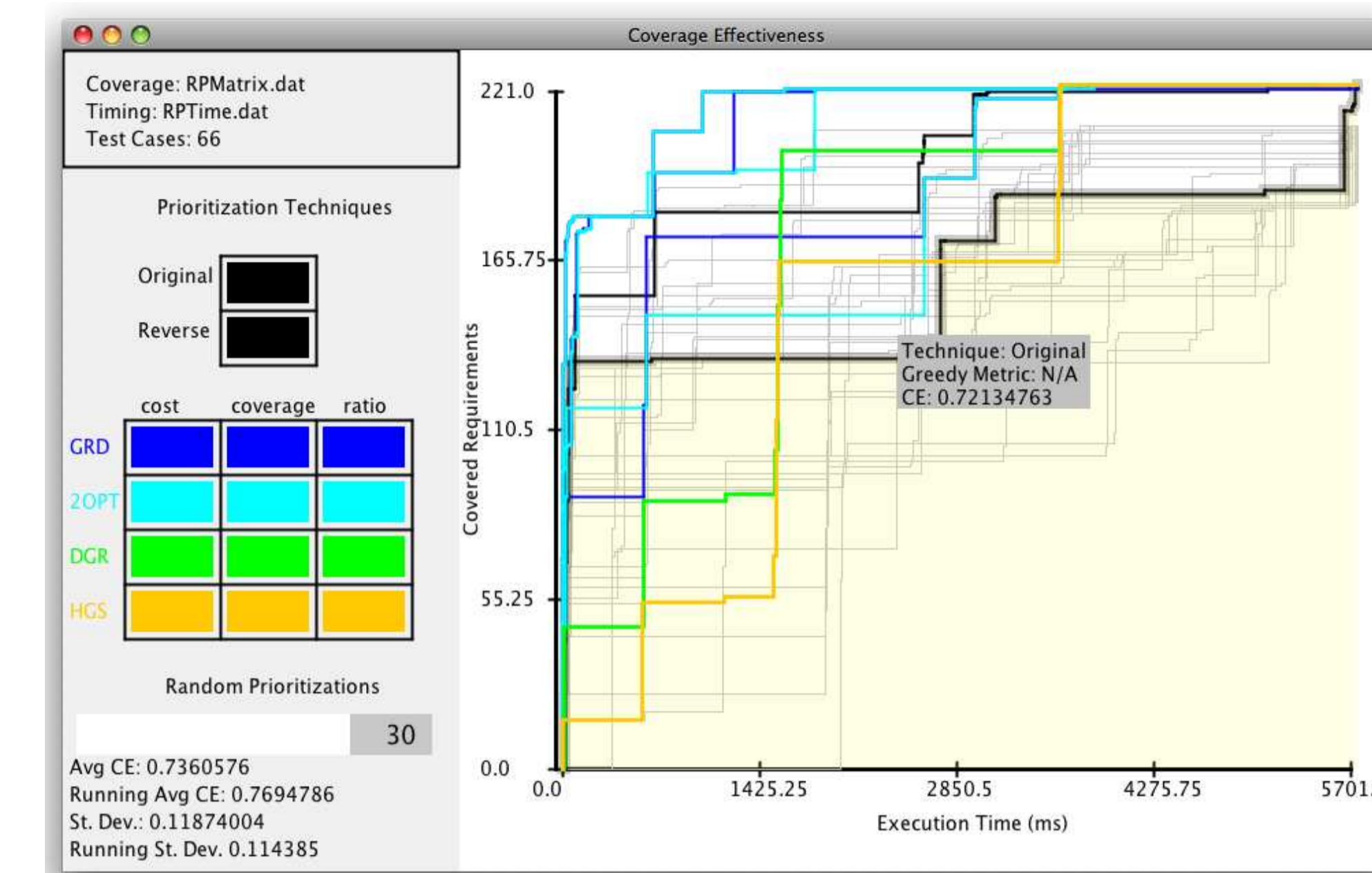


Figure 6: Interactive Coverage Effectiveness Multiplot in RAISE. Visualization using Interactive Multiplots and details on demand allows the users to quickly filter, evaluate and compare prioritized test suites.

### Left Panel

- ▶ Displays information about the test suite and controls multiplot display
- ▶ Toggle display of cumulative coverage functions for each prioritization method
- ▶ Color coding of prioritization techniques for easy identification
- ▶ Adjust the number of random prioritizations
- ▶ Display cumulative averages and standard deviations of random prioritizations

### Right Panel

- ▶ Multiplot of cumulative coverage step functions of all selected prioritization methods
- ▶ Mouse-over of plots highlights the line and shades the area under the line
- ▶ Mouse-over a line reveals its corresponding prioritizer, GCM, and CE score
- ▶ Vertical axis to display the number of covered requirements and horizontal axis to show the test suite execution time

## CONCLUSIONS AND FUTURE WORK

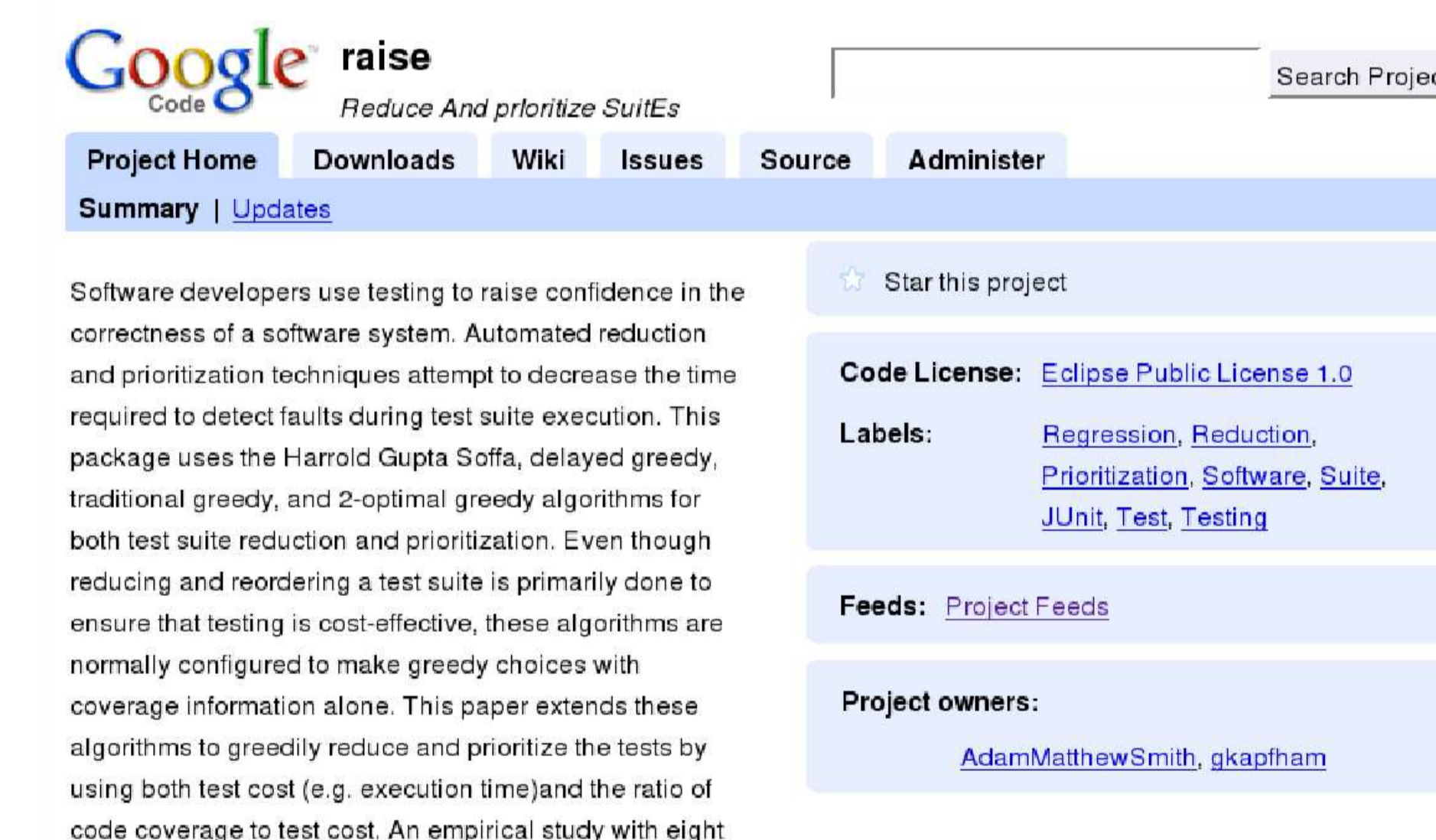


Figure 7: <http://raise.googlecode.com/> provides tools, data sets and resources.

- ▶ An **interactive** visualization that enables the **evaluation** of prioritized regression test suites
- ▶ Free and open source **Reduce And prioritize SuitEs (RAISE)** system available for download
- ▶ Intend to add new **features** and conduct more experimental **studies**
- ▶ Will **extend** RAISE to support other **metrics** like average percentage of faults detected (APFD) and average percentage of requirements covered (APRC)
- ▶ RAISE will serve as a **simple** and **valuable** tool in a comprehensive framework supporting all of the phases in the **regression testing** process

## REFERENCES

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