International Journal of Engineering Studies and Technical Approach
ISSN No. 2395-0900

Test Case Prioritization for Regression Testing Based on Fault Dependency and Fault Severity

Sumon Chatterjee* & M. Mohan**

**M. Tech, Department of Computer Science and Engineering, SRM University, NCR Campus*

***Assistant Professor, Department of Computer Science and Engineering, SRM University, NCR Campus*

ABSTRACT

The sole purpose of Test Case Prioritization technique is to schedule test cases for Regression Testing in a certain order that increases the effectiveness of the testing process while achieving some performance goal. It ensures that the most beneficial test cases are executed first. A number of techniques have been proposed for Test Case Prioritization. One of the techniques prioritizes test cases based on Fault Dependency. This technique helps the developers to start debugging on the faults that cause other fault sto appear later. The only limitation of this approach is that the fault severity is considered uniform, which in practical world may often vary. So, this paper aims to resolve it by considering fault severity along with fault dependency and thus further improving the performance of the regressiontesting process.

Keywords – *Fault Dependency, Fault Severity, Regression Testing, Test Case Prioritization.*

I. INTRODUCTION

Regression testing is the re-execution of some subset of tests that have already been conducted to ensure that changes have not propagated unintended side effects [6]. Regression testing ensures that there is no additional error introduced due to the modification of the software. Regression test suites are usually previously designed and saved for later reuse. But, re-executing all the test cases can take an enormous amount of time leading to overall inefficiency of the process. To improve the efficiency, either of test suite reduction, test case selection or test case prioritization is used [7].

Test case prioritization sorts the test cases in a prioritized order based on some selection criterion. Several criteria can be considered for prioritization e.g., fault dependency, fault severity, code coverage etc. Fault dependency is the property of a fault to cause other faults to appear later. Independent faults can be directly detected and removed, but mutually dependent faults can be removed if and only if the leading faults have been removed. In regression testing if the test cases that reveal the faults of output module execute first and test cases reveals faults of input module executes later then it will be delayed and in many cases will take long time to detect the original cause of output faults. If the dependencies can be detected earlier in regression testing then debugging can be started earlier and fault removal time will improve [1]. Fault severity helps in early detection of severe faults to improve the software quality with respect to business value. This research aims to integrate fault severity with fault dependency to improve the efficiency of the regression testing process.

ISSN No. 2395-0900
International Journal of
Engineering Studies and Technical Approach

II. RELATED WORK

In recent years, many metrics have been proposed by researchers to improve regression testing. One such metric is proposed in [3] and [4], to measure fault detection rate as objective function along with statement coverage. The metric proposed in [2] deals with varying test case and fault costs. Prioritization of test cases using relevant slices is proposed in [5].In [1],a metric is proposed that measures fault dependency detection rate.The proposed technique first determines the number of faults dependent for each fault and then calculates total dependency count for each test case. The value of total dependency count determines the sorting order of the test cases.

III. PROBLEM DESCRIPTION

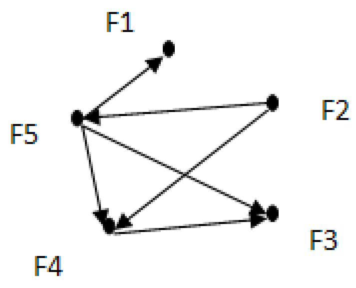
The existing technique proposed in [1], prioritizes test cases based on Fault Dependency. This technique helps the developers to start debugging on the faults that cause other faults to appear later. The only limitation of this approach is that the fault severity is considered uniform, which in practical world may often vary. This paper aims to resolve it by considering fault severity along with fault dependency and thus further improving the performance of the regression testing process.

IV. PROPOSED METHODOLOGY

A. Existing Approach Considering Fault Dependency

Fault dependencies are represented in [1] with directed graph, G (V, E). The vertex set V represents the faults, V= {V1, V2, V3, V4, V5}. The edge set E represents fault dependencies where an edge (F1, F2) represents fault F1 is dependent on fault F2. “Fig. 1” shows the dependency graph, as shown in [1].

Fig. 1. Dependency Graph



The dependency matrix, M, from [1],is formed from the graph where M (i, j) =1 if fault Fi is dependent on fault Fj and M (i, j) =0 if Fi is not dependent on fault Fj.

ISSN No. 2395-0900
IJESTA International Journal of Engineering Studies and Technical Approach

Table 1. Dependency Matrix

	F1	F2	F3	F4	F5
F1	0	0	0	0	0
F2	0	0	0	1	1
F3	0	0	0	0	0
F4	0	0	1	0	0
F5	1	0	1	1	0

From the dependency matrix M, NFD (F) i.e., Number of Faults Dependent on fault F, is calculated for each fault.

Test cases with fault detecting abilities are also considered in [1] which is shown in Table 2.

Table 2. Exposure of Fault Matrix

	F1	F2	F3	F4	F5
T1	*				
T2		*			
T3		*			*
T4			*		
T5	*			*	*

From dependency matrix and exposure of faults matrix, Total Dependency Count (TDC) is calculated for each test case. TDC of a test case is the summation of NFD of faults that first expose in the test case [1]. Then test cases are sorted in descending order of TDC value.

B. New Prioritization Technique Considering Fault Dependency and Fault Severity

The fault dependency component of the proposedprioritization factor is derived as described in [1].For the fault severity component, each fault is assigned a Severity Measure (SM) based on five classes as shown below:

1) Very Low (Severity Measure = 1): Class S1
2) Low (Severity Measure = 2): Class S2
3) Moderate (Severity Measure = 3): Class S3
4) Complex (Severity Measure = 4): Class S4
5) Critical (Severity Measure = 5): Class S5

Then, severity matrix is formed based on the categories of faults for each test case, as shown in Table 3:

ISSN No. 2395-0900
International Journal of Engineering Studies and Technical Approach

Table 3. Severity Matrix

	S1	S2	S3	S4	S5
T1	1	1	1	0	0
T2	1	0	1	1	1
T3	0	1	1	0	0
T4	0	0	0	0	0
T5	0	0	1	1	0

Total Severity Count (TSC) for each test case is calculated from the summation of Severity Measures (SM) of all faults identified for the test case.

$$TSC = \sum_{i=0}^{n} SM. \tag{1.1}$$

Prioritization Factor (PF) is calculated for each test case, which is the summation of the two components i.e., Total Dependency Count (TDC) and Total Severity Count (TSC).

$$PF = \sum_{i=0}^{n} (TDC + TSC). \tag{1.2}$$

Using the value of the Prioritization Factor (PF), the algorithm sorts the test cases in the descending order of PF to generate the required test case prioritization order of regression testing based on fault dependency and fault severity.

C. Algorithm

The algorithm for the new prioritization technique considering fault dependency and fault severity, which is the modified form of the algorithm proposed in [1], is shown below:

*Input:*Test suite T, Fault dependency matrix M, Fault exposure matrix E, Fault severity matrix FS, Fault F

*Output:*Prioritized test suite T’

```
1:  begin
2:      set T’ empty
3:      set NFD empty
4:      set TDC empty
5:      set TSC empty
6:      set PF empty
7:      for each fault f’∈ F do
8:          for each fault f’’∈ F do
9:              if M [f’, f’’] =1 then
10:                 NFD [f’’] =NFD [f’’] + 1
```

ISSN No. 2395-0900
International Journal of
Engineering Studies and Technical Approach

```
            end if
        end for
    end for
    for each test case t ϵ  T do
        for each fault f ϵ  F do
            if f first exposes in T then
             TDC[t] =TDC[t] + NFD[f]
            end if
            TSC[t] = TSC[t] + FS[f]
        end for
        PF[t] = TDC[t] + TSC[t]
    end for
    sort T in descending order based on the PF value of each test case
    let T' be T
end
```

The algorithm first calculates the NFD of each fault based on fault dependency matrix M. Then, TDC of each test case is determined from the fault exposure matrix E and the derived NFD. TSC for each test case is calculated from the fault severity matrix FS. Then, PF for each test case is determined from the summation of its TDC and TSC. Finally, based on the value of PF, test cases are sorted in the descending order of PF to generate the required test case prioritization order of regression testing based on fault dependency and fault severity.

V. EXPERIMENTATION AND ANALYSIS

Let us take the fault dependency graph from "Fig. 1", fault dependency, fault exposure and fault severity tables i.e., Table 1, 2 and 3 respectively as inputs.

From Fig. 1, we have the following six dependencies E= {(F2, F4), (F2, F5), (F4, F3), (F5, F1), (F5, F3), (F5, F4))}.

The NFD of each fault calculated from Table 1 are shown below:

NFD (F1) =1
NFD (F2) =0
NFD (F3) =2
NFD (F4) =2
NFD (F5) =1

After calculating TDC of each test case from Table 1 and 2,we get the following:

TDC (T1) = NFD (F1) = 1
TDC (T2) = NFD (F2) = 0
TDC (T3) = NFD (F5) = 1
TDC (T4) = NFD (F3) = 2
TDC (T5) = NFD (F4) = 2

TSC for each test case is calculated from Table 3 by adding up the corresponding SM of faults, which is shown below:

TSC (T1) = 1 + 2 + 3 = 6

TSC (T2) = 1 + 3 + 4 + 5 = 13

TSC (T3) = 2 + 3 = 5

TSC (T4) = 0

TSC (T5) = 3 + 4 = 7

Prioritization factors for each test case is calculated by the summation of TDC and TSC as shown below:

PF (T1) = TDC (T1) + TSC (T1) = 1 + 6 =7

PF (T2) = TDC (T2) + TSC (T2) = 13

PF (T3) = TDC (T3) + TSC (T3) = 1 + 5 = 6

PF (T4) = TDC (T4) + TSC (T4) = 2

PF (T5) = TDC (T5) + TSC (T5) = 2+ 7 = 9

Now, sorting test cases in descending order of PF, we get the following prioritized order of test cases: T2, T5, T1, T3 and T4.

After plotting graph of the percentage of fault dependency and severity detected versus the percentage of test suite executed, we get "Fig. 2" for unsorted test cases and "Fig. 3" for prioritized test cases.

Fig. 2. Graph for Unsorted Test Cases

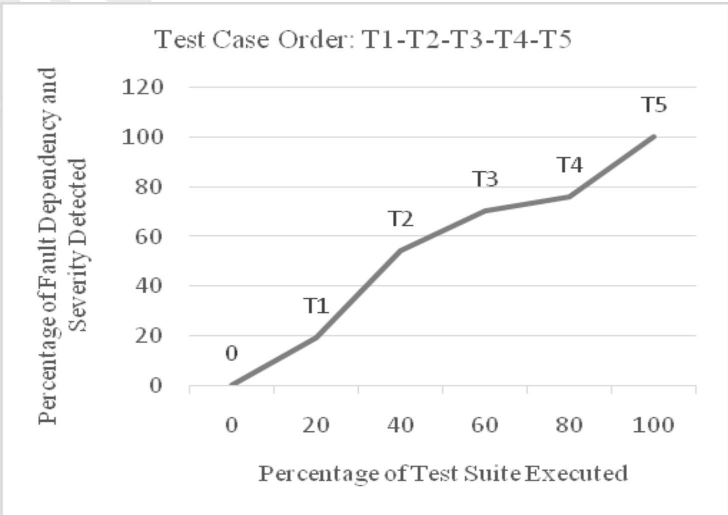
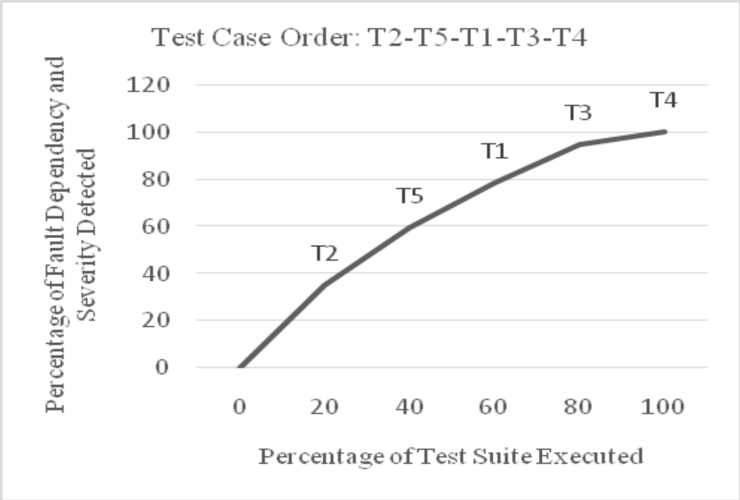


Fig. 3. Graph for Prioritized Test Cases



From “Fig. 2” and “Fig. 3”, we see that the area coverageof the fault dependency and severity detection for the prioritized test cases is much better than that for the unsorted test cases, which implies the significant performance increase in the test case prioritization process based on fault dependency and fault severity.

VI. CONCLUSION AND FUTURE WORK

This paper proposed a technique to prioritize test cases based on fault dependency and fault severity. Several other parameters e.g., code coverage, can alsobe incorporated with this approach. Also, genetic algorithms can also be implemented to generate a better pool of input test cases. Test case execution time is also considered uniform here. These factors can be considered to make this algorithm more robust and effective.

ACKNOWLEDGMENT

This work was supported by the Department of Computer Science and Engineering of SRM University, NCR Campus. We would like to thank all the faculty members of our department for their relentless encouragement and support throughout the whole research process.

REFERENCES

i. Md. ImrulKayes, “Test Case Prioritization for Regression Testing Based on Fault Dependency”, Electronics Computer Technology (ICECT), 3rd International Conference, IEEE, 2011

ii. Alexey G. Malishevsky, Joseph R. Ruthruff, Gregg Rothermel, Sebastian Elbaum, “Cost-cognizant Test Case Prioritization”, Technical Report TR-UNL-CSE-2006-004, Department of Computer Science and Engineering, University of Nebraska–Lincoln, Lincoln, Nebraska, U.S.A., March 2006.

ISSN No. 2395-0900

iii. S. Elbaum, A. Malishevsky, and G. Rothermel, “Prioritizing test cases for regression testing,” Proc. The 2000 ACM SIGSOFT International Symposium on Software Testing and Analysis, Portland, Oregon, U.S.A., August 2000, 102–112.

iv. S. Elbaum, A. Malishevsky, and G. Rothermel, “Test case prioritization: A family of empirical studies,” IEEE Transactions on Software Engineering, vol. 28(2), 2002, pp. 159–182.

v. D. Jeffrey and N. Gupta, “Test case prioritization using relevant slices,” Proc. Computer Software and Applications Conference, 2006, 411–420.

vi. Roger S. Pressman, “Software engineering a practitioner’s approach”, 7/e, 2010

vii. UshaBadhera, G.N Purohit, Debarupa Biswas, “Testcaseprioritization algorithm based upon modified code coverage in regression testing**”,** International Journal of Software Engineering & Applications (IJSEA), Vol.3, No.6, November 2012

viii. B. Qu, C. Nie, B. Xu, and X. Zhang, “Test case prioritization for black box testing,” Proc. Computer Software and Applications Conference, July 2007, 465–474.

ix. B. Korel, G. Koutsogiannakis, and L. H. Tahat, “Model-based test prioritization heuristic methods and their evaluation,” Proc. International Conference on Software Maintenance, 2007, 34–43.

x. B. Korel, L. Tahat, and B. Vaysburg, “Model based regression test reduction using dependence analysis,” Proc. International Conf. on Software Maintenance, 2002, 214–223.