Chapter 7

Conclusions

7.1 General discussion

The research work described in this thesis has shown concern over the rate of severe fault detection in requirement based system testing and proposed test case prioritization techniques and prioritization metrics for facilitating both new testing and regression testing. The above has been done to improve the user satisfaction, the rate of severe fault detection and to reduce cost and time of testing. Five different prioritization techniques have been developed in this thesis by obtaining the factors that influences the requirements and the requirement coverage information viz.

1. Test Case Prioritization (TCP) based on the requirement factor values
2. TCP based on values and factor weights
3. TCP based on test case cost
4. TCP based on Fuzzy logic
5. TCP based on Genetic Algorithms

The first four techniques prioritize the test cases based on the requirement factor values and the last technique prioritizes regression test cases based on the requirement coverage information and test case execution time. The factors that influence the requirements are identified by conducting postmortem analysis with two programs. Factors that are incorporated in the proposed prioritization technique are viz. Customer assigned priority of requirements, Developer-perceived code implementation complexity, Changes in requirements, Fault impact, Usability, Application Flow, Completeness and Traceability. The contribution of each of the prioritization factors towards the test efficiency is
examined. Test efficiency is a measure of the percentage of failures detected over the period of test suite execution.

The proposed, TCP technique based on factor values, has been built to prioritize the test cases based on their weights. In order to compute the weights of the test cases, the weights of the requirements are computed with the assigned value of requirement factors and the test cases are mapped to their corresponding requirements. Test cases are the prioritized based on their computed weights. The performance of proposed TCP technique based on factor values has been measured with two proposed metrics viz. ASFD and ATEI. The proposed ASFD metric is used to measure and compare the rate of severe fault detection of the proposed TCP technique based on factor values technique and the existing random ordering technique by experimenting five student projects and two industrial projects. Sign test for statistical analysis is also conducted to prove the effectiveness of the proposed prioritization technique. Also with two industrial case studies, the rate of severe fault detection of the proposed TCP based factor value is compared with the existing statement coverage and method coverage based prioritization techniques. The proposed ATEI metric is used to measure the average effort to detect the induced faults in several faulty programs.

For better prioritization, the factor weights are used to compute the test case weights in the proposed, TCP technique based on factor weights. The assigned factor values are used to compute the factor weights. The effectiveness of the factor weight based prioritization technique is also measured with the proposed ASFD and ATEI metrics.

The proposed, TCP technique based on test case cost, improves the requirement coverage in minimum cost. Two Algorithms viz. additional requirement coverage based test case prioritization algorithm and total requirement coverage based test case prioritization algorithm, have been proposed. The effectiveness of these proposed algorithms are measured by the
The proposed metric $\text{ReqSatTcc}$. The rate of requirement weights satisfied per unit cost is evaluated by the proposed metric. The effectiveness of the proposed TCP based on test case cost is also measured by the proposed ATEI metric.

The prioritizations of test cases are made more accurate by using soft computing techniques for prioritization. In the proposed TCP technique based on fuzzy logic, the fuzzy input functions viz. Low, Medium and High are assigned as values of the requirement factors. Fuzzy rule are computed with input membership function and requirement factors. Then the rule to be fired is computed and the output membership value of the rule is considered as a requirement weight. These requirement weights are utilized to compute test case weights by mapping the test cases to the requirements. The effectiveness of the factor weight based prioritization technique is also measured with the proposed ASFD and ATEI metrics. Results indicate that the proposed technique leads to improved rate of fault detection of severe faults in comparison to random ordering of test cases. Sign test is conducted to investigate the null hypothesis that the TPFD for the proposed prioritization techniques are no better than that for a randomly chosen technique and alternate hypothesis that the TPFD for the proposed prioritization technique is greater than that for a randomly chosen order.

In the proposed TCP technique based on genetic algorithm, the test cases are prioritized to improve rate of fault detection. Fitness value is computed, based on the coverage information and maximum time allotted to the test suite. Selection, crossover, mutation, addition and deletion are processed based on the computed fitness value. These processes are repeated until all the test cases in a test suite are considered to obtain the prioritized order. The effectiveness of the proposed genetic algorithm based technique is measured with the existing validation metric called ASFD by conducting experiments on two standard programs. The effectiveness of the proposed genetic algorithm based technique is
also measured by the proposed ATEI metric. Finally, ATEI values for the five proposed prioritization techniques are compared. On an average, the proposed prioritization techniques execute only 50% of the total test cases executed by random ordering technique, to detect the induced faults. On comparison it is also proved that the prioritizations based on soft computing techniques are better.

The research works described in this thesis have individually proven to be effective by exhaustive experimentation.

7.2 Scope for Future research

The following suggestions may be taken up for further research in Test case Prioritization.

In future, it is planned to do further empirical studies to evaluate the proposed prioritization techniques and validation metrics, providing data to propose more rigorous guidelines. In some systems, such as the safety-critical systems, the requirement factor values, requirement weight and test cost estimation approaches may not satisfactorily capture the characteristics. In these cases, it is needed to study the approach to adjust the distributions of requirement weight and test cost.

In GA based technique, if coverage can be calculated at a finer level of granularity, a different method could be used to calculate fitnesses of individuals within the genetic algorithm. For example, if coverage information could be written in detail for each test case so that the union of the test case coverage could easily be determined. Further, this information could be used to calculate incremental coverage instead of running Emma every time. Such an improvement is likely to speed up the genetic algorithm considerably.

Future research could also be carried out using varied values for crossover probability and mutation probability. Fault tree analysis that could be used to decide how much to penalize a prioritized test subsuite could also be investigated for better APFD values.