A Test Development/Enhancement Methodology for Large Software System

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Abstract—**Linear sequential waterfall model of Software Development Life Cycle provides clear and well-defined procedures, processes and guidelines that should be followed for any software development. The development begins with user requirement elicitation phase and goes through software requirement specification, high-level design, detailed design, coding, testing, and warranty. The accompanying test planning for this typical development model that begins at the user requirement phase for unit testing, integration testing, system testing and acceptance testing is well known and well practiced for software development. Any test development methodology which does not come under the purview of the above software development model, poses its own challenges in terms of defining a specific test development/enhancement methodology to meet product quality requirements in terms of test objective, scope, entry, exit and validation criteria.**

The following research paper talks about a solution, that can be deployed in coming up with a suitable test development and enhancement methodology for a large software system which is already available in the market and serving a large customer base. The methodology proposes a model for development of tests, targeting specific features perhaps identified as problem areas, having large number of customer reported defects.

1. Introduction

The test development/enhancement methodology needs to make a thorough study of the customer usage of the software, analyze the history of customer reported defects and define an effective test development/enhancement methodology, to meet the test objective.

The large software product that is being considered will typically have some collection of feature test cases, which would have evolved over a period of time.

The methodology proposed here focuses on defining a model where the activity starts with a study to understand the essence of customer scenarios and requirements, to understand the feature, the feature test cases available, how the feature has been implemented, and what the customer expectations are.

2. Critical Test Areas

The first step that needs to be taken up is to undertake a comprehensive analysis of customer defects over a period of time, and came up with a list of most critical test areas where there have been large concentrations of customer reported defects. An analysis of the customer defects identifies a number of commonly occurring problem areas. Assuming that the analysis identified following test areas for which test enhancement or creation of new test suites will be required.

- Feature 1
- Feature 2
- Feature 3
- Feature 4
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3. Test Development/Enhancement Model

Having identified the broad areas of test development/enhancement, it is necessary to came up with a test development/enhancement methodology that would provide a unified approach and a defined processes flow for the test development/enhancement cycle.

The development/enhancement of the tests in the identified test area can follow the development model of

- Defect Analysis & Feature Map Study
- Test Design Specification
- Test Development through Feature Map (Black Box) Model

- Code Coverage data collection and Coverage Map Study
- Test Improvement through Coverage Map (White Box) Model
- Test Reports & Test Metrics

3.1 Defect Analysis & Feature Map Study

This phase of test development/enhancement will consist of study of

- Requirements document
- Feature external specification document
- Feature test specification document
- Defect analysis reports of customer encountered problems
- Existing feature test suites

The study of the above documentations and existing feature test cases will allow the test developer an understanding of the feature, the feature test cases available, how the feature has been implemented, and what the customer expectations are, what the customer encountered problems in the area are.

Based on the study of the above, following analysis documents could be generated at the end of this phase.

- A Defect Analysis document of all customer reported defects in the identified test area to understand the customer scenarios and requirements. The customer defect analysis findings are to be captured in a specific template for subsequent analysis in the test design phase. The customer defect analysis document contains the defect reported in the test area, an understanding of the essence of the problem, severity of the defects, analysis and comments from developers and test engineers. This will provide an understanding about the deficiencies found in the implementation of the feature, from a perspective of customer usage of the feature.

- A Feature Analysis document of relevant feature test cases if available and generation of a feature map containing test scripts that map to a collection of features being tested based on examination of available test scripts and feature specification document. The feature map can be used to identify and analyze the gaps that can be attempted to fill in, from a perspective of implementation of the feature. This is generated

in a specific template which will be used during subsequent phases.

Feature map contains the main feature, sub-features tested, the name of the test file in which the corresponding test cases are available, any new feature identified as not being covered in the existing test files, information about existence of any customer defects in the identified area. Information in this document will be used in the subsequent test design phase.

- A Test Plan document would be generated from Defect Analysis document and Feature Map document, containing a list of features identified as not covered in the existing test suite. The document contains list of features to be added while developing new test cases based on examination of Defect Analysis document and Feature Map document.

- Customer Type Data Sets document, containing how customer-like data sets are to be generated for creation of new test cases.

The deliverables from this phase would be

- Defect Analysis Document
- Customer Type Data Sets Document
- Feature Map Document
- Test Plan

3.2 Test Design Specification

Based on analysis of Defect Analysis Document, Customer Type Data Sets document, Feature Map Document and Test Plan generated in the preceding phase, following design specification documents could be generated

- Test Data Design Specification document, containing a description of how customer-like datasets is to be created. The document is used to generate the test setup scripts required for the test development.

- Test cases Design Specification document, containing the features to be tested, test files to contain the specific feature test cases, and description of test cases to be created under each features.

The deliverables from this phase would be

- Test Data Design Specification
- Test cases Design Specification

3.3 Test Development through Feature Map (Black Box) Model

Based on Test Data Design specification and Test cases Design specification generated in the test design specification phase, Test Setup scripts and Test Scripts are developed.

The deliverables from this phase would be

- Test Setup Scripts
- Test Scripts

3.4 Code Coverage data collection & Coverage Map Study

A list of source files, implementing the specific feature is to be identified from relevant Detailed Design document. Code coverage data for developed test cases at the end of preceding phase, are to be collected on all the identified source files.

A Coverage map containing a list of source files and corresponding coverage is to be created, which will be used in the subsequent phase.

3.5 Test Improvement through Coverage Map (White Box) Model

The Coverage map is to be studied to analyze the coverage on each source files. If coverage on some of these files are not sufficiently high, a detailed study of those source files are to be undertaken to understand the specific sub-features

being implemented by them, from information available in detailed design document. Existing test cases are to be modified, or new test cases are developed to increase coverage on those files, based on understanding of features being implemented, as given in detailed design document.

Here tests are to be enhanced based on White Box approach, where new test cases will be developed based on study of coverage on the source files, and the features being implemented by them, rather than trying to have a detailed understanding of the code (loops, conditions, flow path).

3.6 Test Reports & Test Metrics

Test Reports & Test Metrics for the test development/enhancement could be generated in terms of

- Number of test scripts written
- Number of setup scripts written
- Number of in-house defects found
- Incremental code coverage
- Overall code coverage

A traceability matrix is to be generated covering all the above development phases to maintain the traceability for all test cases.

3.7 Management Plan for Test Development/Enhancement

Stage	Inputs	Work Products
Defect Analysis & Feature Map Study		
• Defect Analysis • Preparation of Feature Map	• Defect Tracking System • Feature External Specification Document • Feature Test Specification Document • Defect Analysis Reports • Available Feature Test Suites	• Defect Analysis Document • Customer Type Data Sets • Feature Map Document • Test Plan Document
Test Design Specification		
• Test Data Design • Test Specification Document	• Defect Analysis Document • Customer Type Data Sets • Feature Map Document • Test Plan Document	• Test Data Design Specification • Test cases Design Specification
Test Development through Feature Map (Black Box) Model		
• Test Data • Test case Development • Testing	• Test Data Design Specification • Test cases Design Specification	• Test Setup Scripts • Test Scripts
Test Improvement through Coverage Map (White Box) Model		
• Code Coverage Data Collection • Preparation of Coverage Map • Test Scripts Enhancement	• Detailed Design Specification Document • Coverage Map Document	• Enhanced Test Scripts
Test Reports & Test Metrics		
• Metrics Data Collection	• Test Setup Scripts • Enhanced Test Scripts	• Metrics Data • Code Coverage Data (Incremental, Overall)

4. Test Plan

An analysis of Customer reported defects, and study of the feature specification documents and features test suites available in the respective test areas, will bring out the gaps in the existing test areas. These observations are to be documented in the form of Test Plans based on close examination of Defect Analysis Document and Feature Map Document.

5. Feature 1 Test Development

This section provides a brief description of the above test development methodology that can be used for creation of test cases in say for example in Feature 1 test area.

Let us assume that Defect Analysis Document showed that not many customers reported defects existed in this area. In addition, Feature Map document showed the availability of a test suite, where test cases available did not test the Feature 1

adequately. A test plan needs to be therefore created, to develop a comprehensive test suite covering all areas of the Feature 1 test area.

Assuming that following features were identified for Feature 1 test development.

- Feature 1.Sub Feature 1
- Feature 1.Sub Feature 2
- Feature 1.Sub Feature 3
- Feature 1.Sub Feature 4

At the end of development of test cases as per the above plan, code coverage data can be collected for these test cases. Detailed design document would have identified following source files implementing Feature 1 feature, for which code coverage data was analyzed. Generated Coverage map may indicated following source files (highlighted below), whose coverage is not sufficiently high.

Feature 1 Coverage (at the end of Feature Map Phase)

Serial No.	Files	Total Number of Lines	Hit Lines	% Hit Lines
1	..mod1/sub1/file1.c	3419	1391	40
2	..mod1/sub1/file2.c	1077	808	75
3	..mod1/sub1/file3.c	737	277	37
4	..mod1/sub2/file4.c	106	64	60
5	..mod1/sub2/file5.c	130	93	71
6	..mod2/sub4/file6.c	18	17	94
7	..mod2/sub4/file7.c	502	397	79
8	..mod2/sub7/file8.c	364	292	80
9	..mod2/sub7/file9.c	915	763	83
10	..mod2/sub9/file10.c	289	92	31
Total Lines		7557	4194	55

Further study of detailed design document would reveal a set of sub features which have not been adequately covered under the feature map phase, which resulted in low coverage for the above source files.

- Test cases related to Feature 1.Sub Feature 5
- Test cases related to Feature 1.Sub Feature 6

- Test cases related to Feature 1.Sub Feature 7
- Test cases related to Feature 1.Sub Feature 8

Hence, additional test cases can be developed to cover above Sub Features of Feature 1 test area which would result in increased coverage for those source files, for which a representative improvement data is indicated below.

Feature 1 Coverage (at the end of Coverage Map Phase)

Serial No.	Files	Total Number of Lines	Hit Lines	% Hit Lines
1	..mod1/sub1/file1.c	3419	3042	88
2	..mod1/sub1/file2.c	1077	808	75
3	..mod1/sub1/file3.c	737	662	89
4	..mod1/sub2/file4.c	106	64	60
5	..mod1/sub2/file5.c	130	93	71
6	..mod2/sub4/file6.c	18	17	94
7	..mod2/sub4/file7.c	502	437	87
8	..mod2/sub7/file8.c	364	292	80
9	..mod2/sub7/file9.c	915	813	88
10	..mod2/sub9/file10.c	289	232	80
Total Lines		7557	6460	85

Same methodology of initial feature map (black box) approach, followed by coverage map (white box) approach could be adopted for development of test cases in each test areas.

6. Benefits of Test Development/Enhancement

- Enhanced testing ensuring robustness of the code
- Higher test coverage and in-house error detection
- Minimize possibility of regression problems
- Reduced overall customer reported problems
- Higher productivity
- Reduced cost on post-release maintenance, rework
- Increased confidence in the testing process and its completeness

7. Conclusion

With test architecting as an emerging discipline and a key focus area, it should be the constant endeavor of every IT companies to lay a strong foundation for innovative test engineering practices and methodologies for testing complex software projects and products. In a competitive market environment like today, with increasing focus on application migration to offshore, as the preferred business model, it is imperative for IT companies to pay adequate attention in evolving effective product testing methodologies. The above research paper makes an attempt come up with a test development model for a large software system. Even though the approach outlined here has been adopted for test development/enhancement for large software system, it can be extended to any software development and maintenance activities irrespective of the size, application area and domain.

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