

Applying Risk Based Testing Methodology in MasterCard Regression Testing
Activity for MasterCard Project

NURSHADA BINTI NGALIM

A project report submitted in partial
fulfilment of the requirements for the award
of the degree of Master of Software
Engineering

Advanced Informatics School

Universiti Teknologi Malaysia

JUNE 2015

To my beloved mother and father

ACKNOWLEDGEMENT

I would like to express my sincere appreciation to my thesis supervisor En Azri Hj. Azmi for his willingness to take me under his wing after the short notice given for Industrial Attachment 2. Not to forget to Dr. Suriayati Chuprat for her encouragement to make me proceed my industrial attachment even after I moved to United States. Her support and supervision online during Industrial Attachment 1 was highly appreciated. In addition I would also like to thank Dr. Nurulhuda Firdaus Mohd Azmi, the Master of Software Engineering program coordinator for her advice throughout my studies in the University.

I am also very thankful to Samir Sahu my industrial supervisor for guidance, advices and motivation throughout this period. I am also indebted to my beloved colleague Effa Anuar for her contribution in providing data for MDS Regression Testing. Without their continued support and interest, this thesis would not have been the same as presented here

My fellow postgraduate students especially to Siti Rosmawati and Nurmaliza Jumaat for providing me support while I am in United States. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. I am grateful to all my family members.

ABSTRACT

The purpose of this project is to implement Risk Based Testing Methodology in MasterCard Regression Suite. This project is to address concern by MasterCard counterpart due constant increase in regression fixed cost. The ever growing regression test suite requires more people to work on the testing which lead to the increasing of the fixed cost. To overcome this problem we decided to implement Risk Based Testing Methodology as one method to define priority test cases from the existing regression suite. The Risk Based Testing approach can be used to categorize the test cases based on its criticality and priority which can be defined using Risk Exposure Factor. Risk Based testing analysis will be performed on MasterCard Regression Testing to identify the critical and complex scenarios then prioritize those scenarios with the appropriate weightages. The criticality and prioritization criteria would consider criteria's like Frequency of Groups Failure based on the defects history, Business criticality and Functionality/Services introduced on the specific release. Identification and Review of Functional Specifications of Business as Usual (BAU) before the release started. An initial estimation on the time and effort will be made through number of scripts from each BAUs. Once weightages assigned by each analyst, a final ranking will be done through a simple multiplication of all weight-ages against a particular requirement. The Risk Exposure Factor is computed by multiplying Impact, Probability and Dependency factors considering the mentioned criteria weight-ages. Test cases with high Risk Exposure Factor will be called as targeted test cases. The implementation of Risk Based Testing in MasterCard Regression suite is proven to effectively find defects and reduced time consumption in execution. 100% of the defects found during 15Q3 release execution through targeted test cases with 25% effort saving which lead to 25% reduced in cost. In addition Risk Based Regression suite is used whenever there is a time constraint in execution and as a smoke or sanity testing from a system.

ABSTRAK

Tujuan projek ini adalah untuk mengaplikasikan teknik *Risk Based Testing* di *MasterCard Regression Suite*. Projek ini adalah untuk menangani permasalahan yang diutarakan oleh MasterCard mengenai kenaikan kos kekal dalam *Regression Testing*. Aplikasi *Risk Based Testing Methodology* adalah penyelesaian yang boleh digunakan untuk mengenal pasti *regression test cases* berdasarkan keutamaan. *Regression Test Case testing* akan dilakukan mengikut keutamaan yang telah ditetapkan. *Risk Based Testing Methodology* adalah salah satu teknik yang biasa digunakan di dalam industri pengujian perisian untuk mengoptimalkan *Regression Suite*. Pendekatan *Risk Based Testing* adalah dengan mengenal pasti *test case* mengikut keutamaan berdasarkan *Risk Exposure Factor*. *Risk Based testing* analisis dilaksanakan pada keseluruhan kitaran hayat software dengan mengenal pasti tahap kepentingan dan kekompleksan. Kemudian scenario akan di khususkan mengikut pemberat. Kriteria yang dia ambil kira dalam pengiraan *Risk Exposure Factor* adalah kekerapan *test case* gagal semasa ujian, kepentingan terhadap perniagaan dan fungsi yang di perkenalkan pada *release* tersebut. *Regression Suite* yang dihasilkan dari *Risk Exposure Factor* akan digunakan dalam pengujian *Regression*. *Regression Suite* yang dihasilkan dari teknik *Risk Based Testing* terbukti mengenal pasti kecacatan pada perisian mampu mengurangkan masa menguji perisian. 100% kecacatan pada 15Q3 *release* dikenal pasti melalui *test cases* prioriti tinggi dan penjimatan 25% kos untuk pengujian perisian. Selain itu, *Risk Based Testing Regression Suite* juga boleh digunakan dalam *smoke testing* dan masa kritikal di mana ada kekangan masa

TABLE OF CONTENTS

DECLARATION	ii
DEDICATION	iii
ACKNOWLEDGEMENTS	iv
ABSTRACT	v
ABSTRAK	vi
TABLE OF CONTENTS	vii
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF ABBREVIATIONS	xii
 CHAPTER 1	 1
INTRODUCTION	1
1.1 Company Background	2
1.1.1 Customer Background	3
1.1.2 MasterCard Project Background	4
1.2 Background of Problem	6
1.3 Project Objectives	9
1.4 Project Scopes	9
1.5 Importance of the Project	10
1.6 Chapter Summary	11
 CHAPTER 2	 12
LITERATURE REVIEW	12
2.1 State of the Art of Software Testing	12
2.1.1 Software Testing in Software Development Lifecycle (SDLC)	14
2.1.2 Software Testing Techniques	15

2.1.3	Software Testing Spectrum	18
2.2	Problem in Regression Testing	19
2.3	Risk Based Testing: Technique for Risk-based Test Case Generation and Prioritization	20
2.3.1	Risk Based Testing Approach	21
2.3.2	Risk Based Testing Evaluation	22
2.4	Specification-based Regression Test Selection with Risk Analysis	23
2.4.1	Risk Based Selection	24
2.4.2	Safety Tests selection method	25
2.4.3	Safety Tests Conclusion	26
2.5	Optimization Approach towards Test Suite Minimization using Bi-Objective Greedy (BOG) Algorithm	27
2.6	Effectiveness of Test Case Prioritization Techniques Based On Regression Testing	29
2.6.1	Prioritization Weight Factors	29
2.6.2	Proposed Prioritization Technique	31
2.6.3	Test Case Prioritization Techniques Evaluation	31
2.7	Comparison on Regression Testing Optimization Technique	32
2.7.1	IEEE Standard for Software and System Test Documentation	37
2.7.2	Risk Based Testing Adopted by Tech Mahindra CFNA-IST project	38
2.7.3	Advantages and Disadvantages of Risk Based Testing	40
2.8	Chapter Summary	42
	CHAPTER 3	43
	PROJECT METHODOLOGY	43
3.1	Introduction	43
3.2	Project Methodology	44
3.2.1	Software Testing Process	44
3.2.2	MasterCard MDS Regression Process	46

3.2.3	Software Tools	50
3.3	Software Documentation Standard	52
3.4	Chapter Summary	52
CHAPTER 4		54
PROJECT DISCUSSION		54
4.1	Output Analysis	54
4.1.1	Data Collection for Risk Based Testing Analysis	54
4.1.2	Risk Based Factor Identification	58
4.1.3	R.E.F Calculation	61
4.1.4	Experiment Results	63
CHAPTER 5		66
CONCLUSION		66
5.1	Constraints	67
5.2	Recommendations	68
5.3	Future Works	68
REFERENCES		69
APPENDICES		75

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	Advantage And Disadvantages Of White Box And Black Box testing (Sawant & Bari, 2010)	16
2.2	Steps In Deriving The Safety Test Cases (Yanping <i>Et Al</i> , 2002)	25
2.3	Comparison On Risk Based And Manual Regression Test Suite	27
2.4	Fault Detected By Test Suites In Bank Project	32
2.5	Summary Of Comparison Between Software Regression Techniques	36
4.1	Risk Exposure Factor (R.E.F) Parameters	59
4.2	Percentage Of Transactions Divided To Each Priority Level	61
4.3	High Priority Test Cases	62
4.4	Total Defects Found By Targeted Test Cases	64
4.5	Summarize On The Rbt Saving Compared To Normal Regression Testing	65

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1.1	Mastercard Core Application Systems	5
1.2	Mastercard Regression Release 2014 Dates	6
1.3	The Percentage Of Mds Regression Growth	7
1.4	The Percentage Of Regression Suite Run Manually Or Unattended	8
2.1	Software Testing In Software Development Lifecycle	15
2.2	The MDS Transaction Testing Flow	18
2.3	Percentage Suite Size Reduction And Percentage Fault Detection Loss	29
2.4	IEEE 829 – 1998 Level Test Plan Outline	38
2.5	IEEE 829-1998 Standard Test Summary Report Template	38
3.1	Waterfall Model Focusing On Testing Area	45
3.2	MDS Regression Flow	47
3.3	MDS Regression Flow (Cont')	48
4.1	Comparison Of Failing Groups And Passing Groups In MDS Regression Suite	56
4.2	Pareto Analysis On The Regression Groups Failure	57

LIST OF ABBREVIATIONS

<i>ATM</i>	-	Automated Teller Machine
<i>BAU</i>	-	Business as Usual
<i>BOG</i>	-	Bi-Objective Greedy
<i>BPO</i>	-	Business Support Services
<i>BSS</i>	-	Business Support Systems
<i>CFNA-IST</i>	-	Citi Finance North America
<i>CMMI</i>	-	Capability Maturity Model Integration
<i>GCMS</i>	-	Global Clearing Management System
<i>HP</i>	-	Hewlett Packard
<i>IEEE</i>	-	Institute of Electrical and Electronics Engineers
<i>MDES</i>	-	MasterCard Digital Enablement System
<i>MDS</i>	-	MasterCard Debit Switch
<i>MHE</i>	-	Member Host Emulator
<i>NASDAQ</i>	-	National Association of Securities Dealers Automated Quotations
<i>OC</i>	-	Onsite Co-ordinator
<i>OSS</i>	-	Operations Support Systems
<i>POS</i>	-	Point of Sale
<i>RE</i>	-	Risk Exposure
<i>REF</i>	-	Risk Exposure Factor
<i>SDLC</i>	-	Software Development Lifecycle
<i>SEI</i>	-	Software Engineering Institute
<i>SME</i>	-	Subject Matter Expert
<i>SOW</i>	-	Scope Of Work
<i>Tech M</i>	-	Tech Mahindra
<i>UAT</i>	-	User Acceptance Test

<i>UFT</i>	-	Unified Functional Testing
<i>UML</i>	-	Unified Modelling Language
<i>UTM</i>	-	Universiti Teknologi Malaysia
<i>US CST</i>	-	United States Central Site Time

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Industrial Attachment 1 Timeline – Gantt Chart	75
B	Industrial Attachment 2 Timeline – Gantt Chart	76
C	Total REF Calculation For Mds Regression Suite Services	77

CHAPTER 1

INTRODUCTION

Regression testing is a vital part of an effective testing process for confirming software quality. It is the process of validating adapted software to provide confidence that the updated parts of the software perform as intended and that the untouched parts of the software have not been adversely affected by the modification described by Harrold *et al.* (2001). Regression testing is important in software maintenance. Tech Mahindra is responsible in providing regression testing service to MasterCard Core Application which is MasterCard Debit Switch (MDS) as part of their Scope of Work (SOW) contract. MDS Regression Suite is developed to test MasterCard DEBIT Switch which is one of the MasterCard applications that used to process card authorization and settlement activity. The regression testing is a critical activity because it is designed to ensure MDS existing functionality does not getting impact on the enhancement introduced for each release. The test cases in the regression are originating from the User Acceptance Test (UAT) test cases that were migrated to the Regression Suite at the end of the release. In each release specific UAT test cases are selected to be added in the regression suite.

MDS Regression Suite is consisting of the test cases that have been there since year 2000 and it evolves every release. Since year 2011, MasterCard had changed its approach to have 4 releases per year instead of two and inducted more projects to keep up with the market growth. As an impact regression suite sizes had increase significantly that requires more resources to work on the testing to meet the dateline.

Despite the automation method implemented in regression activity, yet effort is still not reduced significantly. It is because regression suite is not able to go 100% automated due to limitation constraint on the automation tool and some other activity is required human intervention to be realized. Through that we decided to implement testing optimization methodology which is called as Risk Based Testing in MDS Regression Suite. This method is used to identify the criticality of the test cases using Risk Exposure Factor (R.E.F) and MDS Regression Suite testing is planned based on the R.E.F decided. By implementing this methodology, we are expecting 20 – 20% regression effort reduction.

1.1 Company Background

Tech Mahindra Limited is an Indian multinational provider of information technology (IT), networking technology solutions and business support services (BPO) to the telecommunications industry. Tech Mahindra is a part of the Mahindra Group conglomerate which founded by Anand Mahindra. The headquarter location is at Pune, Maharashtra, India. In 2014, Tech Mahindra was able to put themselves ranked #5 in India's software services (IT) firms and overall #39 in Fortune India 500 lists published in Compendium (2014).

Tech Mahindra combined entity has 95,729 employees across 51 countries, servicing 632 customers globally. It has 15 overseas offices for business process outsourcing (BPO) operations and software development. Its revenue for 2012-13 was put at \$2.7 billion (Rs. 162 billion) published in Tech Mahindra Press Release in January 2014.

Tech Mahindra has operations in more than 30 countries with 17 sales offices and 13 delivery centers and currently assessed at SEI CMMi Level 5.

1.1.1 Customer Background

MasterCard Incorporated (NYSE: MA) or MasterCard Worldwide is an American multinational financial services corporation headquartered in the MasterCard International Global Headquarters, Purchase, New York, United States. The Global Operations Headquarters is located in O'Fallon, Missouri, United States, a suburb of Saint Louis, Missouri. MasterCard principal business is to process payments between the banks of merchants and the card issuing banks or credit unions of the purchasers who use the "MasterCard" brand debit and credit cards to make purchases throughout the world,. MasterCard Worldwide has been a publicly traded company since 2006. MasterCard Worldwide was a cooperative owned by the 25,000+ financial institutions that issue its branded cards preceding to its initial public offering stated in NASDAQ (2012). MasterCard, originally known as Interbank/Master Charge, was formed by several California banks as a competitor to the BankAmericard issued by Bank of America, which later became the Visa credit card issued by Visa Inc. Since 1966 to 1979, MasterCard was called "Interbank" and "Master Charge"

A forerunner of the payments industry, MasterCard has an extraordinary legacy of success and innovation. Over the decades, MasterCard has demonstrated a commitment to making commerce faster, more secure and more convenient, while fostering relationships that drive value for all stakeholders and advance global commerce. MasterCard Business Model is divided into three parts. Franchisor is building business partnership through the thousands of financial institutions that are MasterCard's customers, the company markets a strong portfolio of brands and products worldwide, including MasterCard, Maestro®, Cirrus® and MasterCard® PayPass™. Through Processor, MasterCard's streamlined and intelligent approach to processing enables efficient commerce on a global scale. Finally is Advisor which MasterCard provides industry-leading insight and solutions that advance commerce on a global scale (MasterCard, 2014).

1.1.2 MasterCard Project Background

Tech Mahindra Malaysia successfully acquired testing project from MasterCard in 2011. The project scope of work (SOW) is to provide testing services to MasterCard. One of the testing tracks acquired by Tech Mahindra is to provide User Acceptance Test and Regression Testing services to MasterCard Core Application. MasterCard Core Application consists of three major systems, Banknet, Mastercard DEBIT Switch (MDS) and Global Clearing Management System (GCMS) as shown in Figure 1.1. Banknet application is responsible in handling transaction processing from credit card point of view. MDS Application is responsible in handling debit card pin and ATM type of transaction. GCMS is responsible in handling settlement transaction between acquirer merchant's bank and Issuer cardholder banks (MasterCard, 2014). This Master thesis will cover Regression Testing for MDS application.

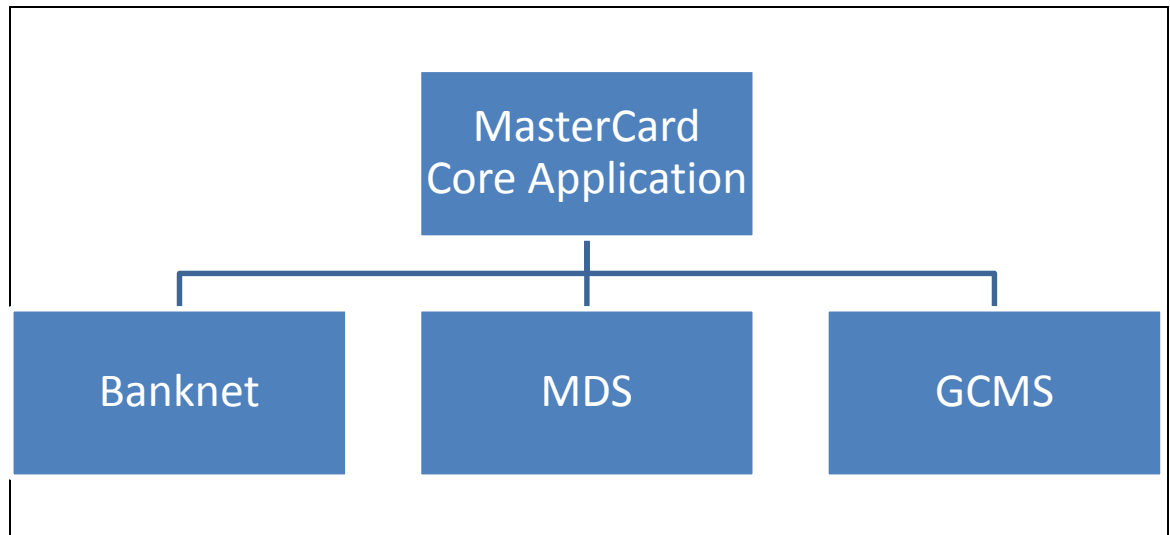


Figure 1.1 MasterCard Core Application Systems

MDS is a system that processing ATM, Pin based type of transaction for MasterCard card brand registered under MDS for example Maestro®, and Cirrus® (MasterCard, 2014). Tech Mahindra is responsible in two testing activity UAT and Regression for core application. MDS Regression executes regression testing in MasterCard Test Facility environment for MasterCard Debit Switch (MDS) application. This to ensure that there is no anomalies in the MasterCard system functionalities in processing the transactions after an enhancement implemented before it goes to production. MDS Regression suite test cases originated from User Acceptance Testing (UAT) test cases. There are about fifty six functionalities that what we called as Service in MDS. In every release the MDS Regression Suite is thoroughly tested to validate if all the MDS existing functionalities behaving as it should. The validation is also checking the behavior of MDS application when communicating with other core application.

In MasterCard, there are four test execution releases scheduled per year which consist of two major and two minor. Major releases are covering product testing that will be release by MasterCard globally and minor releases are covering product testing for specific region or technology. The time line is set for the each release as shown in Figure 1.2 as for 2014 release example. The duration for major

release is 12 weeks and minor release is 6 weeks. Every major release requires regression suites to be executed in 3 iterations which duration for iteration is 4 weeks. During minor release, regression requires executing regression suites in 2 iterations which duration for iteration is 3 weeks.

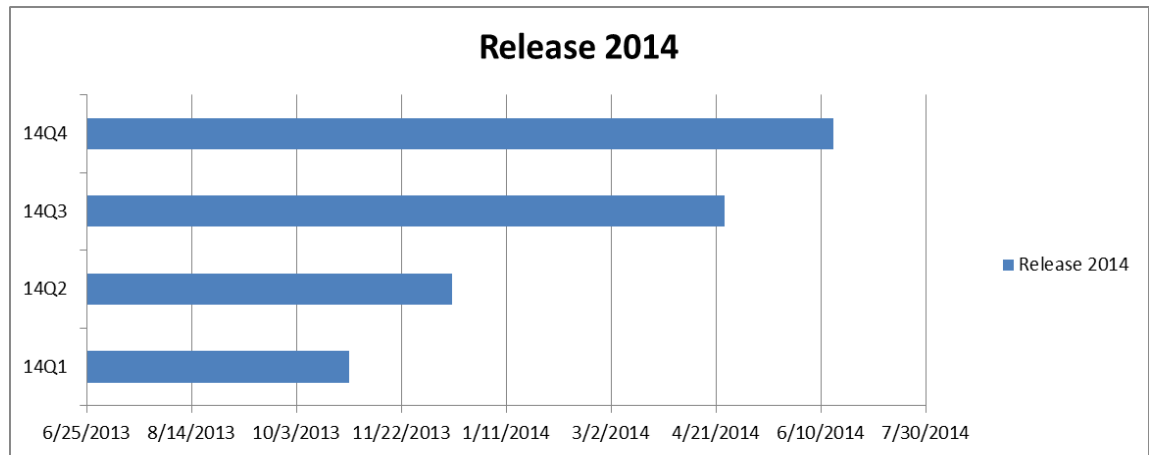


Figure 1.2 MasterCard Regression Release 2014 dates

1.2 Background of Problem

MasterCard Core Line Manager approached Tech Mahindra MasterCard TCOE Project Deliver Manager on her concern with the increased of the regression fixed cost. As the regression Suite is growing therefore more resources are involved in regression activity that contribute to the increased in the regression fixed cost. She was requesting Malaysian team to come up with any process improvement that can be implemented to reduce the fixed cost.

In each release, the same test cases in regression suite will be executed in addition to the new added test cases. Currently there are more than 3000 test cases existed in regression suites and it keeps growing each releases as shown in Figure 1.3. Within a year time span we can see more that 42% growth in number of test

cases. We are expecting the continuation growth in the future. It would be difficult to engage less number of resources in MDS Regression Activities the fix time span.

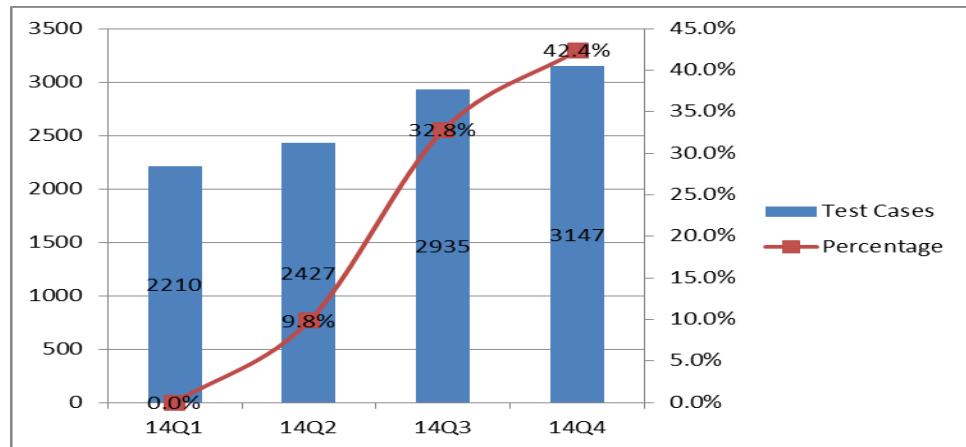


Figure 1.3 The percentage of MDS regression growth

As for the current process, regression suite is executed in two methods; manual and automated. Figure 1.4 showed the percentage of the regression suite stand in execution procedure. 60% of the test cases from MHE are executed automated unattended daily. That is what we normally called as unattended regression. The remaining test cases are executed manually. The unattended regression is done by setting the transaction in the simulator to be run at specific time without human intervention. The remaining of the test cases is executed manually. In addition other activities such as defects analysis and pulling results for all the test cases are done manually which requires human intervention.

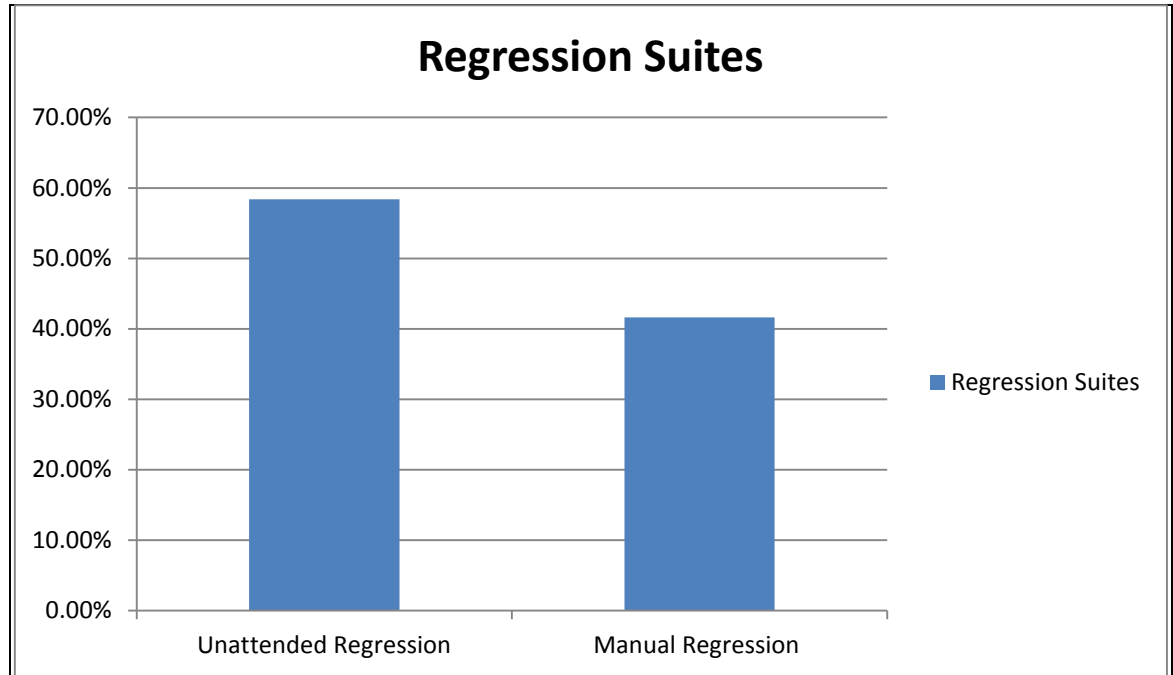


Figure 1.4 The Percentage of Regression Suite Run Manually or Unattended

The issue that hinders regression suite to go 100% automation, Tech M resource is working in a virtual environment run by Citrix. The virtual environment is not stable to make it difficult to use automation tool. Automation effectively works in stable environment. Automation tool has limitation in recognizing fields in other tool use for testing like Mainframe and Tandem.

To overcome this delivery challenge, MDS team introduced **A Risk Based Testing Methodology** to provide an approach to identify and prioritize the critical scenarios. The analysis on determining the criticality of the test cases reference stakeholders input, regression historical data and business criticality.

1.3 Project Objectives

The objectives of this project are as follows:

- i). To study the Risk Based Testing methodology.
- ii). To analyze the MDS regression historical data, stakeholders inputs and the impact on business criticality.
- iii). To develop appropriate Risk Based testing approach to be implemented in MDS Regression Suit.
- iv). To evaluate the effectiveness of targeted test cases derived from this Risk Based Testing in detecting defects.
- v). To produce Software Engineering Documents
 - a) Software Test Plan
 - b) Software Test Summary Report

1.4 Project Scopes

MasterCard Regression Testing Optimization – Risk Based Testing Methodology industrial attachment project is an initiative to implement Risk Based Testing Methodology in MDS Regression Suite as a method of optimizing regression Suite. This project will include analysis on the regression historical data starting from 14Q1 until 15Q1 and assessing the test cases critically based on MasterCard Business Perspective. The activity will include Risk based design analysis on the test cases in effort in determining the Risk Exposure Factor that defined level of criticality of the test cases in producing the optimized regression suite, regression test planning, testing of the optimized MDS Regression Suite, analysis on the Regression Test Results and Test Closure Activity. The implementation of Risk Based Testing methodology in MDS Regression Suite is targeted in 15Q3 Iteration 1 Release. This project only covers Regression Testing in User Acceptance test level performed in MasterCard Integrated Test Facility Environment. At the end of the Risk Based

Testing Methodology in Regression Suite, we are expecting 20% to 25% reduction in regression effort.

The scope does not include preparing requirement for the testing. It does not include preparing or designing the test cases for the regression suite as the plan is to optimize the existing test cases in regression suite. This project does not involve any other testing level including unit test, system test and integration testing.

1.5 Importance of the Project

The implementation of Risk Based Testing Methodology in MDS Regression Suite shows Tech Mahindra proactive approach in providing solution with regards customer concern as well as it showcases Tech Mahindra interest in exploring innovative arena. This approach is expecting 20-25% reduction in regression effort which will solve the initial issue raised by customer. Reduction of the regression effort will provide opportunity for Tech Mahindra to obtain 20% to 30% additional work beyond of regression scope in future with same team capacity due to the 20-25% reduction in regression effort. Through implementation of risk based testing, MDS regression suite coverage can be maximize with lowest possible time and effort. This approach is also flexible which the priority and criticality of the test cases can be modified depending on Risk Exposure Factor which determined with taking stakeholders input as one of the criteria. This will ensure that customer voice is taken care in this process.

REFERENCES

- Aashish, W. (2015). *Large Deals support Tech Mahindra's growth momentum Q3 constant currency revenue growth at 4.9% QoQ 19.6% YoY*. Tech Mahindra.
- Abhijit, A. S., Pranit H.B., Chawan P. M.. (2012) *Software Testing Techniques and Strategies* International Journal of Engineering Research and Applications Vol. 2, Issue 3, May-Jun 2012, pp.980-986
- Adtha, L.,(2002). *The Theory of Software Testing*. Department of Information Technology, Faculty of Science and Technology Assumption University, Bangkok, Thailand 35-40 (Jul. 2012)
- Alam, M.M and Khan, A.I (2008). *Risk-based Testing Techniques: A Perspective Study*. CMJ University, Shillong, Meghalaya, India
- Bassil, Y. (2011). *A Simulation Model for the Waterfall Software Development Life Cycle*. LACSC – Lebanese Association for Computational Sciences Registered under No. 957.
- Compendium (2014) *Ranking of Top 500 Companies*.

- Eldon, Y. L., (1990). *Software Testing In A System Development Process: A Life Cycle Perspective*. Journal of Systems Management, 41 (8), August 1990, 23-31
- Fischer, K. (1977). *A Test Case Selection Method For The Validation Of Software Maintenance Modifications*. International Computer Software and Applications Conference (COMPSAC '77). 421–426. IEEE Computer Society Press.
- Gaurav, D. and Bharti, S. (2008), *Understanding Regression Testing Techniques*.
- Glenford, L. M. (1979). *The Art of Software Testing*, Wiley-Interscience.
- Harenton, K. N. L and Lee J. White. *A Cost Model to Compare Regression Test, Strategies*. Proceedings of the Conference on Software Maintenance. 201-208.
- Harrold, M. J. and James, A. (2001). *Regression Test Selection for Java Software*, Proceedings of the ACM Conference on OO Programming, Systems, Languages, and Applications (OOPSLA '01).
- Humphrey, W. S. (1995). *A Discipline for Software Engineering*. Addison Wesley, New York, NY, USA.
- Ian, S. (2010). *Software Engineering*. Addison Wesley, 9th ed.
- International Journal of Engineering & Technology (iJET) (2012). ISSN: 2049-3444, Vol. 2, No. 5.
- IEEE Computer Society. *IEEE Standard for Software and System Test Documentation IEEE* (2008). New York, USA

- James, B. (1998). *Good Enough Quality: Beyond the Buzzword*. IEEE Computer, August. 96-98.
- Jovanovic and Irena (2008). *Software Testing Methods and Techniques*. May 26,2008.
- Laurie, W. (2011). *A (Partial) Introduction to Software Engineering Practices and Methods*. NCSU CSC326 Course Pack 2010-2011 (Seventh) Edition.
- Lu, L. (2007). *Software Testing Techniques*. Technology Maturation and Research Strategies School of Computer Science Carnegie Mellon University
- McMaster, S., and Memon, A. (2008). *Call-Stack Coverage for GUI Test Suite Reduction*. IEEE Trans. Software Eng. 34. 99-115.
- MasterCard (2007). *MHE User Manual*. MasterCard Publication.
- MasterCard (2008). *Execution Process*. MasterCard Publication.
- MasterCard (2009). *MasterCard DEBIT Switch Overview*. MasterCard Publication.
- MasterCard (2013). *MasterCard DEBIT Switch Execution Process*. MasterCard Publication.
- MasterCard (2014). *Customer Interface Specification*. MasterCard Publication.

- MasterCard (2014). *Single Message System Specification*. MasterCard Publication.
- MasterCard (2015). *Company Insight*. MasterCard Publication. MasterCard (2007). *Basic Authorization Concepts and Authorization Message Flow*. MasterCard Publication.
- Munassan, N.M.A and Govardhan, A. (2012). *A Comparison Between Five Models Of Software Engineerin*. Ph.D Student of Computer Science & Engineering Jawahrlal Nehru Technological University Kukatpally, Hyderabad- 500 085, Andhra Pradesh, India.
- Muthusamy T. and Dr. Seetharaman.(2014). *Effectiveness Of Test Case Prioritization Techniques Based On Regression Testing*. International Journal of Software Engineering & Applications (IJSEA), Vol.5, No.6, November 2014
- Nursimulu, K.; and Probert, R.L. (1995). *Cause-effect graphing analysis and validation of requirements*. Proc. Conf. of the Centre for Advanced Studies on Collaborative Research (CASCON), IBM Press, Toronto, Ontario, Canada, 7-9
- Parsa, S. and Khalilian, A. (2010). *On the Optimization Approach towards Test Suite Minimization*. International Journal of Software Engineering and Its Applications.
- Quadri, S.M.K and Farooq, S.U. (2010), *Software Testing –Goals, Principles, and Limitations*, International Journal of Computer Applications (0975 –8887) Volume 6– No.9, September 2010.

- Quadri, S.M.K and Farooq, S.U. (2011), Testing Technique Selection: A Systematic Approach. Proceeding of 5th National Conference; INDIACom -2011
- Quadri, S.M.K. and Farooq, S.U. (2011). *Evaluating Effectiveness of Software Testing Techniques With Emphasis on Enhancing Software Reliability*. Journal of Emerging Trends in Computing and Information Sciences VOL. 2, NO. 12, December 2011 ISSN 2079-8407
- Rothermel, G. and Harrold, M. J. (1996). *Analyzing Regression Test Selection Techniques*. IEEE Transactions on Software Engineering, Vol. 22, No. 8, August. 529-551.
- Rothermel, G., Harrold, M. J., Ostrin, C. Hong (1998). *An Empirical Study of the Effects of Minimization on the Fault Detection Capabilities of Test Suites*. Proceedings of the International Conference on Software Maintenance, IEEE Computer Society.
- Rothermel, G. and Harrold, M. J. (1994), *Selecting Tests and identifying Test Coverage Requirements for Modified Software*. In Proceeding of the ACM international Symp. On Software, pp-169-184, August 1994
- Royce, W. (1970). *Managing the Development of Large Software Systems*. Proceedings of IEEE WESCON 26.1-9.
- Sharma, P. (2014). *Risk Based Testing: Technique for Risk-based Test Case Generation and Prioritization* .International Journal of Software and Web Sciences (IJSWS)
- Tech Mahindra (2014). *Tech Mahindra Annual Report (2013-14)*. Tech Mahindra Limited.

Tech Mahindra (2015). Our Company. Tech Mahindra Limited

Unnati, B., (2012) *Risk Based Testing* 102

Yanping, C., Robert, L. Probert, D. Sims P. (2002). *Specification-based Regression Test Selection with Risk Analysis*. School of Information Technology and Engineering University of Ottawa, Canada.

Zhang X. Chen, Z., Xu, B., and Nie, C. (2008). *A Novel Approach for Test Suite Reduction Based On Requirement Relation Contraction*. Proceedings of the 2008 ACM symposium on Applied computing. ACM, Fortaleza, Ceara, Brazil.
