MODEL BASED FRAMEWORK FOR MEASURING SERVICE LEVEL AGREEMENT PERFORMANCE IN SERVICE ORIENTED ARCHITECTURE

ALAWI ABDULLAH AHMAD AL-SAKKAF

A thesis submitted in fulfillment of the
requirements for the award of the degree of
Doctor of Philosophy (Computer Sciences)

Faculty of Computing
Universiti Teknologi Malaysia

AUGUST 2013

I declare that this thesis entitled "Model *based Framework for Measuring Service Level Agreement Performance in Service Oriented Architecture"* is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : _____

Name : ALAWI ABDULLAH AHMED AL-SAkkAF

Date : 01-August-2013

For my mother and father

To my supervisors and sponsor

ACKNOWLEDGEMENT

In preparing this thesis, I was in contact with many people, researchers, academicians. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my main thesis supervisor, Dr. Dayang Norhayati Binti Abang Jawawi, for encouragement, guidance, critics and friendship. I am also very thankful to my co-supervisor Professor Dr. Robert Colomb for their guidance, advices and motivation. Without their continued support and interest, this thesis would not have been the same as presented here.

Do not forget all my life, my beloved friend Abdolgaffar Hamed Ahmed, that the impact of the significant impact in my life. He provided me with deep to understanding of specialization. as well as the impact in the understanding of the way to the knowledge of the Creator. Where I am touch from his characteristics high-level and sophistication.

I am also indebted to Universiti Teknologi Malaysia (UTM) for funding my Ph.D. study. librarians at UTM and for all services. My fellow postgraduate students should also be recognised for their support. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. I am grateful to all my family members.

ABSTRACT

Service-Oriented Architecture (SOA) which manages remote service under a third party or provider is a new paradigm for building IT systems. In SOA, the increasing demand for cross-organizational services has highlighted the need for Service-level Agreement (SLA) and monitoring of its service level (performance). Although the role of machine-readable SLA languages like Web Service Level Agreement (WSLA) is recognized, but, the engineering of monitors is complex because it uses the code-based approach. Therefore, research on effective designs of monitors for SOA environment and providing standards in the instrumentation process would improve SOA. This thesis proposed a model-based engineering approach to raise the abstraction and re-use levels for designing standard monitors with automation support. Model Driven Architecture (MDA) was used to automate the development of the software product (monitor). This was done by mapping a business model called Platform Independent Model (PIM) into Platform Specific Model (PSM) using Query View Transform (QVT) as the standard language. In this approach the PIM metamodel is stemmed from WSLA while the PSM is borrowed from SEI framework. Model-based testing was used to generate tests as an artifact which is a requirement for the 6-element framework. As a design science research, an email system case study was used to evaluate the framework. The results showed that Model-based engineering provided a standard method for developing monitors that has raised the abstraction and eventually led to a maintainable and reusable framework. PSM would also act as the standard implementation model for configuring monitors using QVT because it is effective and could configure a number of monitors by reusing the same artifacts (proposed PIM and PSM) requiring less human intervention. Besides that, the PIM metamodel can be extended to accept different SLA languages. The research has proven that the proposed models are not only the best means of communication between SLA stakeholders, but are the core engineering assets for both human and machine because they could reduce engineering effort.

ABSTRAK

Reka bentuk Berorientasikan Perkhidmatan (SOA) yang menguruskan kawalan perkhidmatan di bawah pihak ketiga atau pembekal adalah satu paradigma baharu untuk pembangunan sistem IT. Dalam SOA permintaan yang semakin meningkat kepada perkhidmatan merentas organisasi telah meningkatkan keperluan untuk Perjanjian Tahap Perkhidmatan (SLA) dan pemantauan tahap perkhidmatan (prestasi). Walaupun peranan bahasa SLA boleh dibaca oleh mesin seperti Perjanjian Tahap Perkhidmatan Laman Sesawang (WSLA) diiktiraf tetapi kejuruteraan monitor adalah kompleks kerana pendekatannya berasaskan kod. Justeru itu penyelidikan mengenai reka bentuk yang efektif untuk memantau persekitaran SOA dan menyediakan standard dalam proses instrumentasi akan meningkatkan SOA. Tesis ini mencadangkan pendekatan kejuruteraan berasaskan model dan tahap penggunaan semula untuk mereka bentuk monitor dengan sokongan automasi. Senibina Berpandukan Model (MDA) digunakan untuk mengautomasikan pembangunan produk perisian (monitor). Ini dilakukan dengan memetakan model perniagaan yang dikenali sebagai Model Paltform Bebas (PIM) dalam Model Platform Khusus (PSM) menggunakan Permintaan Paparan Berubah (QVT) sebagai bahasa standard. Dalam pendekatan ini metamodel PIM berasal daripada WSLA manakala PSM dipinjam daripada kerangka kerja SEI. Pengujian berasaskan model telah digunakan untuk menjana ujian sebagai artifak yang menjadi keperluan kepada kerangka kerja enam elemen. Sebagai reka bentuk penyelidikan sains kajian kes melalui e-mel telah digunakan untuk menilai kerangka kerja tersebut. Hasil kajian menunjukkan bahawa kejuruteraan berasaskan model menyediakan satu kaedah standrad dalam pembangunan monitor yang meningkatkan pengabstrakan dan menghasilkan kerangka kerja yang mudah diselenggara dan digunakan semula. PSM juga akan bertindak sebagai model pelaksanaan standard untuk mengkonfigurasi monitor menggunakan QVT kerana PSM berkesan dan boleh menetapkan beberapa monitor menggunakan semula artifak yang sama (yang dicadangkan PIM dan PSM) dengan sedikit campur tangan manusia. Selain itu metamodel PIM boleh dilanjutkan untuk menerima bahasa SLA yang berbeza. Kajian telah membuktikan bahawa model yang dicadangkan bukan sahaja cara terbaik komunikasi antara pemegang saham SLA tetapi merupakan aset kejuruteraan teras kepada manusia dan mesin disebabkan boleh mengurangkan usaha kejuruteraan.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	xii
	LIST OF FIGURES	xiii
	LIST OF ABBREVIATIONS	xv
	LIST OF APPENDICES	xvi
1	**INTRODUCTION**	**1**
	1.1 Overview	1
	1.2 Background of the Problem	3
	1.2.1 SLA languages	4
	1.2.2 SLAs management and evaluation	4

1.2.3 SLA Life Cycle 5
1.2.4 The need for measurement and assessment of SLA 5
1.3 Statement of the Problem 7
1.4 Objective of the Study 11
1.5 Scope 11
1.6 Motivation 12
1.7 Theses Organization 12

2 LITERATURE REVIEW 14
2.1 Introduction 14
2.2 Software Architecture 15
2.3 Performance Parameters 15
2.3.1 Performance Definitions and Classification 16
2.3.1.2 Performance Models from Scenarios 16
2.4 SEI 6-Element Framework 17
2.5 Service-Oriented Architecture (SOA) 19
2.5.1 Languages for SOA 20
2.6 Service Level Agreement (SLA) 21
2.6.1 SLA languages elements 23
2.6.1.1 Web service level agreement (WSLA) 24
2.7 SLAs for SOA Environments 24
2.8 SLA Life Cycle 26
2.8.1 SLA Template 26
2.9 Testing SOA systems 27
2.9.1 SOA Infrastructure 27
2.9.2 Web Services 27
2.9.3 Perspectives, Roles, and Responsibilities 28
2.10 SOA Infrastructure Testing Challenges 28
2.10.1 Service Challenges 29
2.11 Environment for testing 30
2.12 Testing Performance non-functional requirement 30
2.13 Model-Based Testing (MBT) 31

2.13.1 Coverage Criteria 33
2.13.1.1 Structural model coverage criteria 33
2.13.1.2 Data coverage criteria 35
2.13.1.3 Combining test selection criteria 36
2.13.2 MBT in the context of SOA 36
2.14 Metamodeling 37
2.15 Model Driven Architecture (MDA) 37
2.16 MDA Process 39
2.17 Query, Views, and Transformations (QVT) 40
2.18 Frameworks and Model-based Approach 41
2.19 Evaluation of Current Monitor Framework and Proposed Approaches of SLA -Monitor elements 47
2.19.1 Related Work 48
2.19.2 Lack of SLA language (standard SLA) 50
2.19.3 Lack of high automation 51
2.19.4 Lack of Standard monitor vocabulary 51
2.19.5 Lack of Model-based approach 52
2.20 Summary 53

3 RESEARCH METHODOLOGY 55
3.1 Introduction 55
3.2 The Research Design 55
3.3 Research Process Framework 57
3.4 Conceptual Framework 62
3.5 Case Study 64
3.5.1 Analyzing Case study Evidence 66
3.6 Summary 66

4 MODEL BASED DESIGN OF THE MONITOR FRAMEWORK 67
4.1 Introduction to the Model based Framework 67
4.2 The principles of the proposed framework 69

4.3 The activities of model-based framework for measuring SLA 71
4.3.1 User view (principle A) 72
4.3.2 MBT (principle B) 79
4.3.3 QVT Mapping Language (principle C) 80
4.3.4 Execution and Report Generation (principle D) 82
4.4 The relationship between 6-element framework (PSM) and WSLA (PIM) 83
4.5 Discussion 85
4.6 Summary 87

5 EVALUATION OF MODEL BASED FRAMEWORK 89
5.1 Introduction 89
5.2 The specification of SLA (WSLA) (Principle A) 90
5.3 SOA system specification 95
5.4 PIM metamodel 97
5.5 PSM metamodel 100
5.6 Service Usage Model and MBT 100
5.7 Mapping PIM to PSM 106
5.8 Toolset and implementation 107
5.8.1 UML Editor 107
5.8.2 Running EMF to generate instances 110
5.8.3 Importing metamodels to QVT toolset 113
5.8.4 Running QVT tool to generate PSM in XMI 114
5.9 Connecting to a Platform 116
5.9.1 Test Cases Representation and Execution 121
5.9.2 Generating Report 124
5.10 Discussion of Results 125
5.10.1 The level of automation 126
5.10.2 The level of reusability 127
5.10.3 The level of abstraction and platform independence 128
5.10.4 The support of standards 129
5.11 Comparisons 129
5.12 Summary 132

6 CONCLUSION AND FUTURE WORK 134

6.1 Introduction 134

6.2 Summary of the Results 134

6.3 Contributions 139

6.4 Future research 139

REFERENCES 141

Appendix A - B 150 - 161