UNIVERSITI PUTRA MALAYSIA

IMPROVING CONSISTENCY OF UML AND ITS IMPLEMENTATION USING REVERSE ENGINEERING APPROACH

VASANTHI A/P KALIAPPAN

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IMPROVING CONSISTENCY OF UML AND ITS IMPLEMENTATION USING REVERSE ENGINEERING APPROACH

By

VASANTHI A/P KALIAPPAN

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ABSTRACT

Software development deals with various changes and evolution that cannot be avoided and it is an important activity in software life cycle because development processes are vastly incremental and iterative. In Model Driven Engineering, inconsistency between model and its implementation has huge impact on the development process in terms of added cost, time and effort. The later the inconsistencies are found, it could add more cost to the project. Thus, this project aim to propose a mechanism and to develop a tool that can improve consistency between UML design models and its C# implementation using reverse engineering approach. A list of informal consistency rules are set to check vertical and horizontal consistencies between structural (class diagram) and behavioural (sequence diagram and use case diagram) UML models against the implemented C# source code. The work deals with reverse engineering of source code using .NET Reflection API and parsing of UML XMI file using C# XMLReader. The inconsistency found between design diagram and source code are presented in textual description and visualized in tree view structure. The project is evaluated via end user evaluation. The contribution of this project is to aid software developers to maintain design models consistency in a faster and correct way and to guide them to take measures to not let design models and source code drift apart.
ABSTRAK

Perubahan dan evolusi di dalam pembangunan perisian tidak dapat dielakkan dan ia merupakan aktiviti penting dalam kitaran hayat perisian kerana proses pembangunan perlu ditambah baik secara berulang. Di dalam pembangunan berdasarkan model, model yang tidak konsisten dengan pelaksanaannya mempunyai kesan besar terhadap proses pembangunan dari segi kos tambahan, masa dan tenaga. Sewaktu projek segera diperlukan dalam jangkamasa pendek, salah faham konsep dan kecuaian pengaturcara boleh menyebabkan model and program mudah menjadi tidak konsisten. Inkonsistensi yang dijumpai pada fasa akhir kitar hayat pembangunan perisian akan menambah kos berlebihan kepada projek. Oleh itu, projek ini bertujuan untuk mencadangkan mekanisme dan membangunkan aplikasi yang boleh meningkatkan konsistensi di antara model UML dan pelaksanaan kod sumber menggunakan pendekatan kejuruteraan balikan. Peraturan tidak formal digunakan untuk memeriksa konsistensi di antara model dan kod sumber C#. UML di dalam format XMI diproses menggunakan C# XMLReader dan .NET Rekflaksi API digunakan untuk pendekatan kejuruteraan balikan. Inkonsistensi yang dijumpai akan dipaparkan kepada pengguna aplikasi melalui keterangan teks dan digambarkan dalam struktur paparan pokok. Projek ini dinilai menggunakan penilaian pengguna akhir. Projek ini dijangka membantu pemaju perisian untuk mengekalkan konsistensi model reka bentuk dengan cara yang lebih pantas dan betul dan membimbing mereka untuk mengambil langkah-langkah untuk tidak membiarkan model reka bentuk dan kod sumber tidak konsisten.
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DECLARATION FORM

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DR NORHAYATI MOHD ALI (Supervisor)
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<th>Description</th>
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<td>UML</td>
<td>Unified Modelling Language</td>
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<tr>
<td>PIM</td>
<td>Platform Independent Models</td>
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<tr>
<td>MDD</td>
<td>Model Driven Development</td>
</tr>
<tr>
<td>MDA</td>
<td>Model Driven Architecture</td>
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<tr>
<td>UCCCT</td>
<td>UML-Code Consistency Checking Tool</td>
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<tr>
<td>XML</td>
<td>eXtensible Markup Language</td>
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<tr>
<td>XSLT</td>
<td>eXtensible Stylesheet Language Transformations</td>
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<td>XMI</td>
<td>XML Metadata Interchange</td>
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1.1 Introduction

This chapter introduces research background and motivation of this project. It also presents problem statements, project objectives, methodology and expected results and contributions of this project. Lastly the chapter concludes with thesis organization.

1.2 Research Background and Motivation

Software life cycle deals with various changes either in software operating environment or requirements. Software evolution cannot be avoided and it is an important activity in software life cycle because development processes are vastly incremental and iterative. Three explicit maintenance activities in software evolution are corrective to fix defect, adaptive to adapt new technologies and environment, and perfective to enhance and improve software quality. In software development, inconsistencies between architectural instruments and the implemented source code might occur due to erroneous implementation of the design architecture or the separate and uncontrolled changes or amendments in the code (Selim Ciraci, Hasan Sozer & Bedir Tekinerdogan, 2012).

To plan and repair these inconsistencies, software developers have to interfere their workflow further to reinvestigate the model changes that contribute to these inconsistencies. Other than fixing inconsistencies, software
developers also have to fix other model changes that were dependent on the erroneous model elements (Alexander Egyed, 2011).

In times where development schedule and timeline are tight or urgently required projects, manual inconsistency detection and fixing may easily breach model consistency conformance due to errors and mistakes made by human or wrong understanding of the model. According to Michael John Decker, Kyle Swartz, Michael L. Collard & Jonathan I. Maletic (2016), the manual recovery of UML class diagrams is a time consuming and expensive operation, which led industries lack of interest in maintenance activities. Also, their study found that most automatic reverse-engineering tools perform poorly. The tools mostly focused on producing simple class diagrams whereby design abstractions were not represented properly and correctly.

In such scenarios, checking consistency between a design model and its implementation is much required to make sure that function of models are implemented as they should be during various changes in software lifetime. Thus, consistency checking can also help in the understanding models, by implementing its design properties which helps developers to use model driven design approaches more effectively.

1.3 Problem Statement

Inconsistencies between UML model and source code could occur due to various changes implemented during the project’s lifetime at source code level but design models were not updated accordingly due to constraints like time, money, resources and separate and uncontrolled evolution (Selim Ciraci, Hasan Sozer & Bedir Tekinerdogan, 2012).
Based on IEEE 2016 Programming Language Spectrum rating, despite being one of the most popular object oriented language among software developers, it is observed that recent researches in inconsistency management has more attention for Java and C++ compared to C#. This has been studied and synthesized in a systematic critique conducted by Raja Sehrab Bashira, Sai Peck Lee, Saif Ur Rehman Khan, Victor Chang & Shahid Farid (2016). Furthermore, it was found that most researches in existing literatures focused more on class, state chart and sequence diagrams compared to use case diagram. Combination of class diagram, use case diagram and sequence diagram are not explored much. The study also reveals that majority of literature for model inconsistencies were done using forward engineering. In contrast to the vertical consistency problems, horizontal consistency problems were more emphasized in studies and researches.

Therefore, this project aim to find a mechanism and to create a tool that can improve consistency between class diagram, use case diagram and sequence diagram and its C# implementation using reverse engineering approach. Informal consistency rules will be adopted to detect and diagnose vertical and horizontal inconsistencies.

1.4 Project Objectives

The objective of this project is to propose a mechanism to detect inconsistencies between structural (class diagram) and behavioural (use case diagram and sequence diagram) UML models against its C# source code implementation using reverse engineering approach. A prototype tool will be
designed and developed to implement the proposed mechanism. The prototype tool will be evaluated via end user evaluation.

1.5 Project Contributions

The main contribution of this research is to propose a mechanism and to develop a prototype tool that can improve consistency between structural (class diagram) and behavioural (use case diagram and sequence diagram) UML models and its C# implementation using reverse engineering approach. A consistency checker tool will be developed to

i) Read UML design class diagram, sequence diagram and use case diagram.

ii) Read C# source code and extract implemented class model

iii) Detect vertical and horizontal inconsistencies between (i) and (ii) using informal consistency rules.

iv) Generate a textual description and tree view visualization of detected inconsistencies.

The outcome of this project work is expected to assist developers to use model driven design approaches more effectively. It is also expected to fill the gaps in model inconsistency management as mentioned in problem statement.

1.6 Scope of Project

This study aims to aid software developers to maintain design models consistency in a faster and correct way to be in line with the source code implementation. The consistency checking is between code implementation in Visual Studio and UML models. Application scope will be C# source code that
is free from any syntax error. The target users of proposed tool are software developers.

1.7 Dissertation Outline

This thesis is structured in accordance to standard thesis outline. It starts with the introduction chapter and ends with conclusion chapter.

In Chapter 2, detailed review of literature is made. Literatures related to UML models, vertical and horizontal consistency checking rules and reverse engineering methods of source code into models are reviewed. This chapter further discuss related works in research area of concern.

Chapter 3 describes the methodology used in this research. It presents an explanation of vertical and horizontal consistency rules of class diagram, sequence diagram and use case diagram. The chapter also discusses about inconsistency detection logic and approaches. This chapter further discuss the research phases and activities in detail.

Chapter 4 introduces the design and implementation of consistency checker tool in detail. Metadata extraction from UML design model and source code are explained in detail. Identification of vertical and horizontal inconsistency are described with support of algorithm used in this project. Some important line of codes in the implementation program were also discussed.

Chapter 5 presents testing and evaluation of consistency checker tool. Tool testing and evaluation has been conducted using 2 case studies. The main focus of testing to identify inconsistencies between UML models and
source code by applying consistency rules on the metadata extracted from both UML model and source code.

Chapter 6 provides conclusion of this research. This chapter outlines limitation of research and some possible future works.
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