UNIVERSITI PUTRA MALAYSIA

ENHANCEMENT OF JOIN POINT DESIGNATION DIAGRAMS (JPDDS) WITH PROCEDURAL LOGIC AND TIMING CONSTRAINT FOR ASPECT-ORIENTED MODELING

BAHRAM ZARRIN
FSKTM 2010 3

ENHANCEMENT OF JOIN POINT DESIGNATION DIAGRAMS (JPDDS) WITH PROCEDURAL LOGIC AND TIMING CONSTRAINT FOR ASPECT-ORIENTED MODELING

By

BAHRAM ZARRIN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

March 2010

To

My beloved father and mother

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

ENHANCEMENT OF JOIN POINT DESIGNATION DIAGRAMS (JPDDS) WITH PROCEDURAL LOGIC AND TIMING CONSTRAINT FOR ASPECT-ORIENTED MODELING

By

BAHRAM ZARRIN

March 2010

Chairman: Rodziah Atan, PhD

Faculty: Computer Science and Information Technology

Aspect-Oriented Software Development (AOSD) is a technology that helps achieve better Separation of Concern (SOC) by providing mechanisms to localize cross-cutting concerns. Aspect-Oriented Modeling (AOM) is a design technique in AOSD which attempts to separate crosscutting concerns in the earliest steps of software development. Queries on join points are an essential part of AOSD. Join point queries are necessary to identify all relevant points in a program at which aspectual adaptations need to take place. Finding appropriate means to designate such sets of relevant join points is a highly active field of research in AOSD.

Join Point Designation Diagrams (JPDDs) are means that visualize join point queries graphically and separately from the adaptation specification. They provide a visual means to constrain the selection of join points based on static and dynamic, structural and behavioral context. Based on the latest researches on JPDDs, it has been lacking of

support in procedural logic by JPDDs such as loops, alternative structures, and conditional branching between object interactions in the selection criteria of the join points. It causes some join points could not be modeled by JPDDs when join point specifications get complex in aspect-oriented programs. There is another issue in JPDDs which is lack of supporting timing constraints in the join points. There is no way or notation to visualize any timing constraint in a JPDD. Since time constraint is a major issue in real time systems, this lack of support makes a gap between real time system design and join point diagrams.

In order to solve the stated problems, three new extension models are introduced in this research based on UML 2.0. Loop Condition Constraint Model (LCCM) and Alternative Constraint Model (ACM) are presented which aim to support procedural logic and reduce the redundancy of the message flows in JPDDs. Time Constraint Model (TCM) is introduced to fill the gap between real time systems and JPDDs.

Some examples are used to evaluate the proposed models. Each example firstly is modeled by JPDDs without the proposed extensions and then is modeled by JPDDs with the proposed extensions. The results of the experiments showed that the proposed extensions are able to support the missing structures and eased the designation of join points. Introducing the proposed extensions in this thesis creates new opportunities in the join point selection research.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENINGKATAN GAMBARAJAH PENERANGAN TITIK GABUNGAN (JPDDS) DENGAN LOGIK PROSEDUR DAN KEKANGAN MASA BAGI PEMODELAN BERORIENTASIKAN ASPEK

Oleh

BAHRAM ZARRIN

Mac 2010

Pengerusi: Rodziah Binti Atan, Phd

Fakulti: Sains Komputer Dan Teknologi Maklumat

Pembangunan Perisian Berorientasikan Aspek (AOSD) adalah teknologi yang membantu mencapai *Separation of Concern* (SOC) yang lebih baik dengan menyediakan mekanisma untuk menentukan tempat bagi titik pertemuan tumpuan (cross-cutting concern). Pemodelan Berorientasikan Aspek (AOM) adalah teknik merekabentuk dalam AOSD yang mencuba untuk memisahkan titik pertemuan tumpuan pada langkah paling awal dalam pembangunan perisian. AOM menggunakan gambarajah Unified Modeling Language (UML) bagi memodelkan sesuatu konsep berorientasikan aspek. Bahagian yang mencabar dalam AOM adalah untuk menentukan pilihan titik gabungan (join point) dan merekabentuk model bagi mereka.

Gambarajah Penerangan Titik Gabungan (JPDDs) adalah cara bagi memperlihatkan pilihan titik gabungan secara grafik dan terasing daripada adaptasi spesifikasi. Ia menyediakan cara visual bagi mengekang pilihan titik gabungan berdasarkan kepada konteks statik dan dinamik, berstruktur dan perilaku. Berdasarkan kajian terkini JPDD, terdapat kekurangan sokongan dalam logik prosedur oleh JPDDs seperti gegelung, struktur pilihan, dan pilihan bersyarat antara interaksi objek dalam kriteria pemilihan titik gabungan. Ia menyebabkan beberapa titik gabungan tidak dapat dimodelkan oleh JPDDs apabila spesifikasi titik gabungan menjadi kompleks dalam aturcara berorientasikan aspek. Terdapat juga isu dalam JPDDs iaitu kekurangan sokongan kekangan masa dalam titik gabungan. Tidak ada cara atau notasi bagi memperlihatkan sebarang kekangan masa dalam JPDDs. Oleh kerana kekangan masa adalah isu utama dalam sistem masa nyata, kekuranagn sokongan ini menyebabkan terdapat jurang di antara reka bentuk sistem masa nyata dan gambarajah titik gabungan.

Bagi menyelesaikan masalah yang dinyatakan, tiga model sambungan yang baharu diperkenalkan dalam kajian ini berasaskan kepada UML 2.0. *Loop Condition Constraint Model* (LCCM) dan *Alternative Constraint Model* (ACM) dipersembahkan yang bertujuan untuk menyokong logik prosedur dan mengurangkan keberulangan aliran mesej dalam gambarajah JPDDs. *Time Constraint Model* (TCM) diperkenalkan untuk mengisi jurang antara sistem masa nyata dan gambarajah JPDDs.

Beberapa contoh digunakan untuk menilai model yang dicadangkan. Setiap contoh pada permulaannya dimodelkan dengan JPDDs tanpa model sambungan yang dicadangkan,

dan kemudiannya dimodelkan dengan JPDDs dengan model sambungan cadangan tersebut. Keputusan ujikaji menunjukkan bahawa sambungan yang dicadangkan mampu untuk menyokong struktur yang hilang dan mempermudahkan penerangan bagi titik gabungan. Memperkenalkan sambungan yang dicadangkan dalam tesis ini mencipta peluang baharu dalam penyelidikan pemilihan titik gabungan.

ACKNOWLEDGEMENTS

I would like to thank my supervisor, Dr. Rodziah Atan for her valuable comments and advice through the course of this research. Her encouragement and professional review helped this thesis and other technical papers to be further improved.

My further gratitude goes to Dr. Muhamad Taufik Bin Abdullah for his great help and technical advices.

Also, my eternal gratitude is owed to my family who have been supportive in everything I have done. In particular, I would like to thank my mother and father for their never ending love and support.

I also want to thank of all my second family members in Malaysia, including all my friends for providing me with great friendship and experience in my academic and social life. Specially, I owe gratitude to my friend, Shahrzad for her impressive help in my thesis. Finally, thanks God for giving me another opportunity to know myself by living in Malaysia.

APPROVAL

I certify that an Examination Committee has met on **date of viva** to conduct the final examination of **Bahram Zarrin** on his **Master of Science** thesis entitled "**Enhancing Join Point Designation Diagrams (JPDDs) With Procedural Logic and Timing Constraint**" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Chairman, PhD
Faculty of Computer Science and Information Technology
Universiti Putra Malaysia
(Chairman)

Examiner 1, PhD
Faculty of Computer Science and Information Technology
Universiti Putra Malaysia
(Internal Examiner)

Examiner 2, PhD
Faculty of Computer Science and Information Technology
Universiti Putra Malaysia
(External Examiner)

External Examiner, PhD
Faculty of Science and Technology
(External Examiner)

HASANAH MOHD GHAZALI, PhD
Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia
Date:

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirements for the degree of Master of Science. Members of the Supervisory Committee were as follows:

Rodziah Atan, Phd
Senior Lecturer
Faculty of Computer Science and Information Technology
Universiti Putra Malaysia
(Chairman)

Muhamad Taufik Bin Abdullah, Phd
Senior Lecturer
Faculty of Computer Science and Information Technology
Universiti Putra Malaysia
(Member)

HASANAH MOHD GHAZALI, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 12 August 2010

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.

_____

Bahram Zarrin

Date:

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACM	Alternative Constraint Model
AOM	Aspect-Oriented Modeling
AOP	Aspect-Oriented Programming
AOSD	Aspect-Oriented Software Development
EMF	Eclipse Modeling Framework
GEF	Graphical Editor Framework
JPDD	Join Point Designation Diagram
LCCM	Loop Condition Constraint Model
NRMF	Number of Redundant Message Flow
OCL	Object Constraint Language
OOP	Object Oriented Programming
OOSD	Object Oriented Software Development
RMF	Redundant Message Flow
TCM	Time Constraint Model
UML	Unified Modeling Language

CHAPTER 1

INTRODUCTION

1.1 Background

Aspect-Oriented Software Development (AOSD) is a novel technique for separating crosscutting concerns that are usually difficult to do in Object Oriented Software Development (OOSD).

In computer science a concern is any piece of interest or focus in a program. Typically, concerns are synonymous with features or behaviors. There are some concerns (like security, logging, etc) which cannot be implemented in a separate module in Object Oriented Software Development (OOSD) and their implementation crosscuts the other modules which is called cross cutting concerns. AOSD introduces some new concepts and artifacts to solve the problem.

Concerns which have crosscutting (like logging and security) with the other concerns and cannot be implemented in separate module are called *aspect*. A part of the code in an aspect which needs to be injected in none-crosscutting modules is called an *advice*. The places of the program which an advice needs to be called in none-crosscutting concerns are called a *join point*. A set of join points is known as a *pointcut*. The crosscutting concerns are separable at the several phases such as design or implementation level.

AOSD has been emerged from the programming level of the software development life-cycle. In the current decade there are a lot of research interests to separate crosscutting in the design level. Aspect-Oriented Modeling (AOM) attempts to separate crosscutting concerns in the earliest steps of software development (design level). A lot of models have been presented based on UML diagrams. Most of them are same in presenting aspect model and base model. The challenging area is to specify join point selection and design model for pointcuts (Stein et al., 2005).

Queries on join points are an essential part of AOSD. Join point queries are necessary to identify all relevant points in a program (i.e. in its code, or during its execution) at which aspectual adaptations need to take place.

Join Point Designation Diagrams (JPDDs) have been introduced as a novel modeling means to represent join point queries graphically and separately from the adaptation specification in distinct model artifacts (Stein et al., 2002). JPDDs provide abstractions to specify queries on classes, their features and relationships, as well as on messages in a program's control flow. They provide a visual means to constrain the selection of join points based on static and dynamic, structural and behavioral context (Stein et al., 2004a).

Join point as the key concept in Aspect-Orientation has been represented by UML 1.x in (Stein et al., 2002) to serve the needs of aspect-oriented designers of aspect-oriented programs. However UML 1.x has many features to designate several diagrams by software designers, but it is not sufficient to handle all of the modeling needs. There is

lack of some functionality as problem in UML 1.x such as lack of procedural logic required for a sequence being modeled or time constraint in sequence diagrams. Since JPDDs are represented base on UML 1.x, they cannot model join point which requires procedural logic and timing constraint.

The UML 2 has addressed these problems in UML 1.x by adding notation elements called Combined Fragment and time constraint (Ximeng, 2007) but JPDDs cannot still model the join points which require procedural logic and timing constraint.

1.2 Problem Statement

According to Stain (2006), problem of JPDDs with respect to join points is lack of supporting in procedural logic by JPDDs such as loops, alternative structures, and conditional branching between object interactions in the selection criteria of the join points. The problem causes some join points could not be modeled by JPDDs when join point specifications get complex in an aspect-oriented programs.

In order to model join points which need these kinds of structures in JPDDs, modelers either could not model them or they have to designate them by repetition of simple JPDD elements (especially message flows) which lead to the redundancy of the applied elements in the diagrams. Message flows are the basic and the most commonly used elements in the behavioral part of JPDD diagrams for showing the interactions between several objects.

Generally designing repeated elements or diagrams is a time consuming and cumbersome task which leads to increase redundancy of the elements in these diagrams.

Another issue of JPDDs according to Stain (2006) is lack of supporting timing constraint in the join points which deal with timing constraints. There is no way or notation to visualize any timing constraint in a JPDD. Since time constraint is a major issue in real time systems, this lack of support makes a gap between real time system design and join point diagrams.

Since JPDDs do not provide procedural logic structures, designation of join points which needs these structures can be done by current JPDDs but they become complex and ambiguous. It means many parts of the join points have to be modeled by repetition of the primary and simple elements that led to redundancy in the model.

On the other hand, JPDDs do not provide any notation for time constraint to support the systems which time is a vital issue in them such as real time systems. Lack of supporting this constraint by JPDDs makes a gap between them and real time system designs.

1.3 Objective

The objectives of this research are:

- To propose an enhanced JPDDs with complex procedural logic that supports loops, alternative, conditional branching structures, and timing constraint.
- To reduce the redundancy of message flows in the behavioral context of JPDDs.

1.4 Research Scope

Figure 1.1 illustrates the summary of the direction in this research where the bold lines represent the direction followed in this thesis to achieve our objectives and the dotted lines represent the other directions that are already considered in previous researches in the area of Aspect-Oriented Software Development.

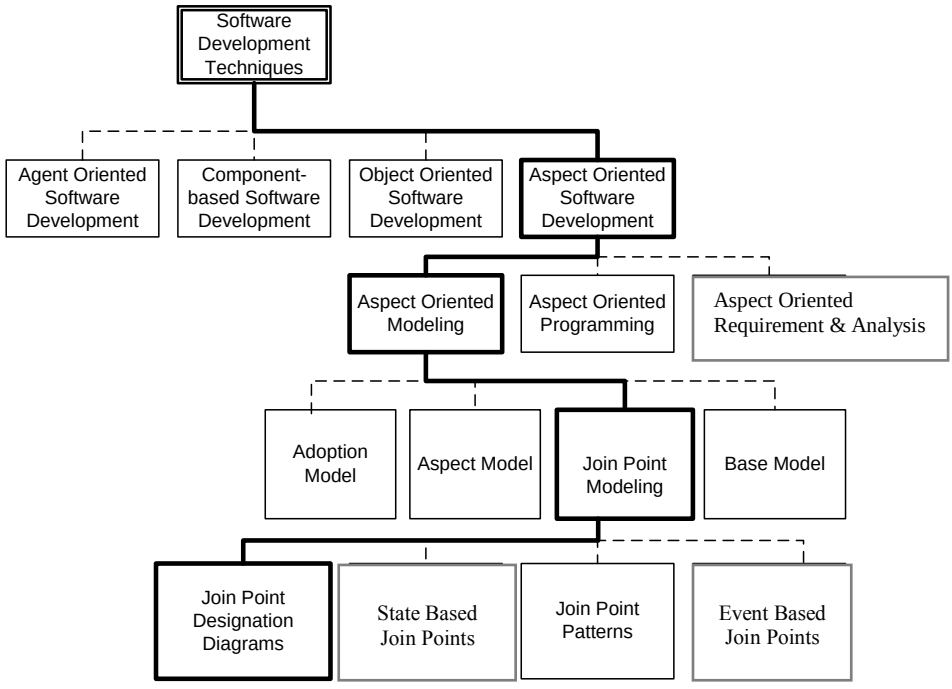

Figure 1.1: Study Module

The focus of this study is on Aspect-Oriented Modeling (AOM) which is the earlier phase of AOSD rather than Aspect-Oriented Programming (AOP). Since join point modeling is the most challenging area among the kinds of aspect-oriented modeling such as base model, aspect model and adoption model, this research concentrates on join point modeling rather than the others.

In join points modeling, developers can have different conceptual models for join points attention to the model nature of their programs such as state based join points, event based join points or interaction based join point. The join points modeling focused in this thesis is interaction based join point which is more common in aspect-oriented programs.

1.5 Overview of Thesis

This thesis is organized in 6 chapters. The chapter 1 provides background of the research including Aspect-Oriented Modeling and Join Point Designation Diagram issues, the problem statement, the objective of the research, the contribution of the work, and the research scope.

Chapter 2 consists of the reviewed literature on the Aspect-Oriented Software Development. Approaches have been presented in this area with a special focusing on Join Point Designation Diagrams.