



# Change Management for Service Based Business Processes

Yi Wang

A thesis submitted in fulfillment  
of the requirements of the degree of

Doctor of Philosophy

Department of Computing

Faculty of Science

Macquarie University

Supervisor: Prof. Jian Yang

April 2011



## ORIGINALITY STATEMENT

I certify that the work in this thesis entitled “Change Management for Service Based Business Processes” has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree to any other university or institution other than Macquarie University.

I also certify that the thesis is an original piece of research and it has been written by me. Any help and assistance that I have received in my research work and the preparation of the thesis itself have been appropriately acknowledged.

In addition, I certify that all information sources and literature used are indicated in the thesis.

Yi Wang

April 2011

To my family.

---

# Acknowledgements

---

This thesis would not have been possible without the support of many people: It is a pleasure to thank them all. First of all, I express my sincere appreciation to my supervisor, Professor Jian Yang, for her continuous support and guidance that have made my research possible. I would like to show my deep gratitude to my co-supervisor, Dr. Weiliang Zhao, for giving insightful and valuable comments about my research and exceptional support during these three and half years of studies. I sincerely thank all the people in the Department of Computing, Faculty of Science, Macquarie University, for their warm support and help. Finally, I am indebted to my parents and my husband for their love, support, and encouragement throughout the whole program of my study. Without them this work would have never been accomplished.



---

# Abstract

---

In the service oriented computing paradigm, business processes and services are subject to change and variation arising from both the external and internal requirements of organizations from time to time. A service change can affect its internal supporting business process and a change occurred in a business process often has various levels of impact on its supported services. This thesis provides research results on the challenging issue of change management for service-based business processes.

Different from existing works in the fields of business process change management, this research focuses on the dependencies between services and business processes. In the real world, there are cases when multiple services are supported by a single business process. The changes of a business process and multiple services can affect each other. The dependencies between services and business process make change management complex and challenging. To manage such changes, it is crucial to identify different types of changes associated with services and business processes, analyse change impact patterns, and then decide the effective mechanisms to deal with them.

In this thesis, a service-oriented business process model is developed for capturing the major characteristics of the required change management in the context

described above. Based on the proposed model, the taxonomy is identified for the changes associated with services and business processes. A set of change impact patterns are specified. Each change impact pattern describes a specific type of change effect. With the help of the change taxonomy, the change impact patterns, and the mechanisms for dealing with individual changes, the cascading effect of changes within the service-based business processes can be analysed. As a proof of concept, a prototype has been developed to realize the change management mechanisms presented in this thesis.



---

# Publications based on this Thesis

---

- [1] Y. Wang, J. Yang, and W. Zhao. Managing Changes for Service Based Business Processes. In Proceedings of the 5th IEEE Asia-Pacific Services Computing Conference, APSCC 2010, 6-10 December 2010, pages 75-82.
- [2] Y. Wang, J. Yang, and W. Zhao. Change Impact Analysis for Service Based Business Processes. In Proceedings of the IEEE International Conference on Service-Oriented Computing and Applications, SOCA 2010, 13-15 December 2010, pages 1-8.
- [3] Y. Wang, J. Yang, and W. Zhao. Service Change Analyzer: An Enabling Tool for Change Management in Service-Based Business Processes, IEEE International Conference on e-Business Engineering, ICEBE 2011, 19-21 October 2011. (accepted)
- [4] Y. Wang, J. Yang, and W. Zhao. A Change Analysis Tool for Service-Based Business Processes, the 12th International Conference on Web Information System Engineering, WISE 2011, 13-14 October 2011. (accepted)
- [5] Y. Wang, J. Yang, and W. Zhao. Change Impact Analysis in Service-Based Business Processes, Service Oriented Computing and Applications. (under revision)



---

# Contents

---

<b>Acknowledgements</b>	<b>v</b>
<b>Abstract</b>	<b>vii</b>
<b>Publications based on this Thesis</b>	<b>ix</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Research Overview . . . . .	1
1.2 Research Background . . . . .	4
1.2.1 Service-Oriented Computing . . . . .	5
1.2.2 Change Management . . . . .	6
1.3 Research Requirements and Issues . . . . .	9
1.3.1 Research Requirements . . . . .	9
1.3.2 Research Issues . . . . .	12
1.4 Contributions . . . . .	15
1.5 Thesis Organization . . . . .	18
<b>2 Related Work</b>	<b>21</b>
2.1 Change Management for Business Processes . . . . .	26
2.1.1 Evolution of Workflow Processes . . . . .	27

---

2.1.2	Flexibility of Business Processes . . . . .	30
2.2	Change Management in Service-Oriented Environment . . . . .	34
2.2.1	Compatibility of Services . . . . .	37
2.2.2	Change Management for Web Services . . . . .	41
2.2.3	Service Evolution . . . . .	45
2.3	Service Adaptation . . . . .	50
2.3.1	Adaptation of Service Interfaces . . . . .	52
2.3.2	Adaptation of Service Protocols . . . . .	54
2.3.3	Flexibility of Service-Based Business Processes . . . . .	58
2.4	Discussion . . . . .	61
<b>3</b>	<b>Service-Oriented Business Process Model</b>	<b>63</b>
3.1	A Motivating Example . . . . .	65
3.2	Service-Oriented Business Process Model . . . . .	67
3.2.1	Process Layer . . . . .	68
3.2.1.1	Control Flow Schema . . . . .	68
3.2.1.2	Information Flow Schema . . . . .	70
3.2.2	Service Layer . . . . .	73
3.2.3	Relations Between Process Layer and Service Layer . . . . .	74
3.3	Discussion . . . . .	78
<b>4</b>	<b>Change Taxonomy</b>	<b>83</b>
4.1	Service Changes . . . . .	84

---

4.1.1	Operation Existence Changes . . . . .	86
4.1.2	Operation Granularity Changes . . . . .	87
4.1.2.1	Asynchronous Operation Granularity Change . .	89
4.1.2.2	Synchronous Operation Granularity Change . . .	96
4.1.2.3	Complex Operation Granularity Change . . . . .	98
4.1.3	Transition Changes . . . . .	101
4.2	Process Changes . . . . .	105
4.3	Discussion . . . . .	116
<b>5</b>	<b>Change Impact Analysis</b>	<b>119</b>
5.1	Overview of Change Impact Patterns . . . . .	121
5.2	Direct Impact Scope . . . . .	124
5.2.1	Direct Impact Scope of a Service Change . . . . .	124
5.2.2	Direct Impact Scope of a Process Change . . . . .	129
5.3	Change Impact Patterns . . . . .	133
5.3.1	Change Impact Patterns for Service Change . . . . .	133
5.3.2	Change Impact Patterns for Process Change . . . . .	141
5.4	Discussion . . . . .	151
<b>6</b>	<b>Change Handling</b>	<b>155</b>
6.1	Handling Individual Changes . . . . .	157
6.1.1	Dealing with Service Change: Add an Operation . . . . .	157
6.1.2	Dealing with Service Change: Delete an Operation . . . . .	159

---

6.1.3	Dealing with Service Change: Modify Operation Granularity	160
6.1.4	Dealing with Service Change: Reordering Transition Sequences . . . . .	162
6.1.5	Dealing with Service Change: Modify Conditional and Looping Transition Sequences . . . . .	165
6.1.6	Dealing with Process Changes . . . . .	166
6.2	Handling Change Propagation . . . . .	168
6.3	Change Isolation . . . . .	173
6.4	Discussion . . . . .	175
<b>7</b>	<b>Service Change Analyser—A Prototype</b>	<b>177</b>
7.1	Architecture . . . . .	178
7.2	Data Structure . . . . .	180
7.3	Components of Service Change Analyser . . . . .	184
7.3.1	Operation Based Analysis . . . . .	184
7.3.2	Transition Based Analysis . . . . .	186
7.4	Running Examples . . . . .	187
7.4.1	Example for Operation Based Analysis . . . . .	187
7.4.2	Example for Transition Based Analysis . . . . .	193
7.5	Discussion . . . . .	196
<b>8</b>	<b>Conclusions and Future Work</b>	<b>199</b>
8.1	Concluding Remarks . . . . .	199

---

8.2	Future Directions . . . . .	203
	<b>Bibliography</b>	<b>205</b>





---

# List of Figures

---

3.1	A motivating example. . . . .	66
3.2	Control flow schema of the sales process. . . . .	69
3.3	Information flow schema of the sales process. . . . .	71
3.4	Services: (a) the service for buyer $s_b$ ; (b) the service for financial institute $s_f$ . . . . .	74
3.5	Examples of internal processes and service. . . . .	75
3.6	(a) Abstract precedence relation; (b)-(e) internal processes. . . .	78
3.7	(a) Abstract parallel relation; (b) internal process. . . . .	79
3.8	(a) Abstract conditional relation; (b) internal process. . . . .	79
4.1	Taxonomy of service change. . . . .	85
4.2	Operation existence change. . . . .	87
4.3	Operation granularity changes. . . . .	89
4.4	AOGC type 1 one-to-one change. . . . .	90
4.5	An example for AOGC type 1 one-to-one change. . . . .	91
4.6	AOGC type 2 one-to-many/many-to-one change. . . . .	92
4.7	Examples for AOGC type 2 one-to-many change. . . . .	94
4.8	AOGC type 3 many-to-many change. . . . .	94
4.9	SOGC type 1 one-to-one change. . . . .	97

---

4.10 SOGC type 2 one-to-many/ many-to-one change. . . . .	98
4.11 SOGC type 3 many-to-many change. . . . .	99
4.12 COGC type 1 asynchronous-to-synchronous change. . . . .	100
4.13 An example for COGC type 1 synchronous-to-asynchronous change. 101	
4.14 Transition sequence order change (TSOC). . . . .	102
4.15 Sequential (parallel) to parallel (sequential) transition sequence change (SPTSC, PSTSC). . . . .	103
4.16 Adding (removing) conditional transition sequence change (ACTSC (RCTSC)). . . . .	104
4.17 Adding (removing) looping transition sequence change (ALTSC (RLTSC)). . . . .	104
4.18 Taxonomy of process changes. . . . .	106
4.19 Serially insert a process fragment. . . . .	106
4.20 Examples of serially inserting an activity. . . . .	109
4.21 Parallel insert an activity. . . . .	110
4.22 Conditionally insert an activity. . . . .	110
4.23 Serially move an activity. . . . .	111
4.24 Parallel move an activity. . . . .	112
4.25 Conditionally move an activity. . . . .	113
4.26 One-to-one replacement. . . . .	113
4.27 One-to-many activities replacement. . . . .	114

---

4.28	Parallelize (sequence) activities. . . . .	114
4.29	Embed an activity in conditional branch. . . . .	115
4.30	Embed an activity in conditional branch. . . . .	115
5.1	Overview of change impact patterns. . . . .	121
5.2	Change impact patterns. . . . .	122
5.3	Structure of the change impact pattern . . . . .	125
5.4	(a) Service change: TSOC in service $s_b$ ; (b) direct impact scope of the service change. . . . .	129
5.5	(a) Process change: replace activities; (b) direct impact scope of the process change. . . . .	132
5.6	Change impact pattern 1 Insert a c-Activity. . . . .	135
5.7	Change impact pattern 2 Remove a c-Activity. . . . .	136
5.8	Change impact pattern 3 Replace c-Activities. . . . .	138
5.9	Change impact pattern 4 Move c-Activities. . . . .	140
5.10	Change impact pattern 5 Add, Remove or Modify Conditional Branches. . . . .	142
5.11	Change impact pattern 6 Add an Operation. . . . .	145
5.12	Change impact pattern 7 Remove Operations. . . . .	146
5.13	Change impact pattern 8 Change Operation Granularity. . . . .	148
5.14	Change impact pattern 9 Change Transition Sequence. . . . .	150

---

5.15	Change impact pattern 10 Add Conditional or Looping Transition Sequence. . . . .	152
6.1	Adapter for solving <i>type A</i> case at operation level. . . . .	158
6.2	Adapter for solving <i>type B</i> case at operation level. . . . .	159
6.3	Reordering activities. . . . .	163
6.4	Using reordering template. . . . .	164
6.5	An example of deadlock when using reordering template. . . . .	165
6.6	Propagation of a service change. . . . .	168
6.7	Propagation of a process change. . . . .	169
6.8	An example for propagation of a service change. . . . .	170
7.1	High level architecture for SCA. . . . .	179
7.2	Entity relationship diagram. . . . .	181
7.3	Hierarchy diagram. . . . .	185
7.4	Browse service operations. . . . .	188
7.5	Choose change types of service operations. . . . .	189
7.6	Add an operation in parallel to an existing operation. . . . .	190
7.7	Impact analysis for the change of adding operation in parallel to an existing operation. . . . .	192
7.8	Browse service transitions. . . . .	193
7.9	Choose change types of service transitions. . . . .	194
7.10	Change transition sequence order. . . . .	195

---

7.11 Impact analysis for change transition sequence order. . . . .	197
--	-----



---

# List of Tables

---

6.1	Structure of reordering template. . . . .	164
-----	---	-----

