Deliberate Cooperation In Service-Oriented Environments: Dynamic Transactional Workflows For Web Services

A thesis submitted to the
University of Newcastle, NSW, Australia
for the degree of
Doctor of Philosophy
(Computer Science)

by

David John Paul
BMath, BCompSc (Hons I)

March, 2012

Statement of Originality

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying subject to the provisions of the Copyright Act 1968.

(David John Paul)

Dedicated to my mother. You showed me the path but let me make my own way.

Acknowledgements

> No man is an island entire of itself; every man is a piece of the continent, a part of the main.
>
> *John Donne*

The city of Newcastle has a lot to offer. Large enough to have most modern conveniences available, but small enough not to have completely lost its village feel, the city combines the coastal lifestyle (including some of the most beautiful beaches in the world) with the industrial contrast that its mining history ensures. It has been my home; I can offer it no greater compliment or thanks. Of course, a location on its own, no matter how beautiful, cannot provide the support necessary for a long-term project such as this dissertation. For that, people are needed, and I've been fortunate enough to have had the guidance, support, and presence of some truly wonderful people, all of whom deserve my acknowledgement and my thanks.

Prominently among these people are my supervisors, Assoc. Prof. Frans Henskens and Dr Michael Hannaford. Their advice, encouragement, and, most of all, friendship, have proved invaluable. I must also thank everybody who has been involved in the Distributed Computing Research Group while I've been here: Mr Ali Alharbi; Mr Bilal Alguni; Dr Monjurul Alom; Ms Mukta Aphale; Mr Aaron Hector; Dr Bayu Hendradjaya; Mr Zainul Masud; Dr Aslam Nasir; Mr Vinh Nguyen; Dr Kim Nolan; Dr Peter Shaw; and Mr Mark Wallis. Especially Mark; your enthusiasm and seemingly undying ability to start work on new interesting problems, no matter how many other things you have going on, has been truly inspirational.

Outside of our research group, but still in the faculty, I owe a great deal to my confirmation committee: Dr Stephan Chalup; Dr Yuqing Lin; Dr Alexandre Mendes; and Dr Joe Ryan. The confirmation process was extremely positive for me, and this work would be much poorer without the excellent advice given after my first year of

postgraduate study. I'm also thankful for the excellent support given by the administrative staff, especially Ms Kathy Allan and Ms Kathy Killen, and the IT support from Mr Geoff Martin, Mr David Montgomery, and Mr Aaron Scott. I also wish to thank the Australian Schizophrenia Research Bank for my employment throughout my candidature, in particular Mr Jason Bridge, Dr Carmel Loughland, and Ms Kathryn McCabe.

In recent years, people have been realising the importance of a work/life balance; external "distractions" are actually beneficial and make a person more complete. For providing such a distraction, I thank Hunteract, the Rotaract Club of the Hunter, and, more recently, the Kiwanis Club of East Maitland. As I've already said, Newcastle still has a very village-like feel to it, and being involved in community service has made me feel worthy to belong; introducing me to some wonderful people was an added bonus. Exercise is equally important for a well-balanced life, and for that I must thank the Ragtags OzTag team and the Rainbow Sneakers netball team. I also thank some others who have made my life easier during the last few years (with "few" having quite a range for some of you): Ms Crystal Debreceny, Ms Nancy Earl, Prof. Maree Gleeson, Mr Geoff Keech, Ms Melanie Patfield, Ms Anastasia Suchowerska, and the Tomkins family (Nathan, Natalie, Gracie, James, and now Henry).

Finally, and most importantly, I offer my undying gratitude to my family, especially my parents John and Helen, my sister Catherine, and my grandmother June. You may not completely understand the process I've been going through, Dad, but you give your love and support anyway. You've had a much better idea Mum, encouraging me along the right path even when it may have seemed that I had lost my way. Catherine, your brilliance and perseverance have been of great influence, and I'll always love you. And Grandma, if I can explain my work to you then I can explain it to almost anybody; thank you for listening and taking the time to understand.

Contents

Abstract

> The only thing that will redeem mankind is cooperation.
>
> *Bertrand Russell*

Modern society is complex and, in order to achieve desired goals, individuals must work together. Cooperation between parties can either be accidental, forced, or deliberate. Deliberate cooperation occurs when individuals realise that a successful outcome is more likely when they team up with others to achieve common goals. This thesis presents a method to support deliberate cooperation in service-oriented architectures. In such an environment, deliberate cooperation can be provided through improved transaction support.

Service-oriented architectures are based on the concept of services. Providers advertise the services that they offer and clients send requests for the services to be performed without needing to understand the intricate details of how the outcomes are achieved. Clients often require services from multiple unrelated providers in order to achieve their goals, but current systems make it difficult to combine these services in such a way that the client is guaranteed an acceptable outcome. Further, the existing standards are not always flexible enough to allow service providers to always offer their desired level of transaction support.

This thesis presents a method that allows service providers to dynamically alter the level of transaction support they offer for their services. This approach is more flexible than current approaches for Web Services transactions, and ensures that providers are always able to offer a level of support for cooperation with which they are comfortable. A formal system is also presented that allows clients to use the transactional guarantees offered by providers to reason about service compositions and ensure that client workflows always end in an acceptable state.

To augment these theoretical results, a Web Services transactions simulator has been developed. By simulating transaction flow rather than service flow, this allows the dynamic transaction scheme described in this thesis to be compared with more traditional Web Services transactions. Results indicate that support for dynamic transactional workflows can provide an overall benefit for both clients and service providers, and the simulator allows detailed study of how changes to the transactional behaviour of participants affects the outcome of particular scenarios.