Foreword by the Institute Director

A major research theme within the Fraunhofer Institute for Applied Information Technology FIT addresses human-centered methodologies for the development and evolution of complex, software-intensive systems, such as cyber-physical systems, infrastructures, and applications. Many of these system classes are quite complex, such that the proposed methodologies need to address multi-project management strategies and, in particular, experience transfer across projects.

In this volume, René Reiners presents evolving pattern libraries as a solution strategy for this challenge. While traditional software patterns as introduced by Gamma et al., and many of their followers in other domains, tend to represent rather stable standard software engineering knowledge, projects in these innovative domains tend to rely on emerging and rapidly evolving rather than stable knowledge, as no standard patterns are yet available. In many cases, these projects also involve stakeholders and developers with culturally diverse backgrounds, due to their interdisciplinary nature as well as due to international cooperation and collaboration between researchers and practitioners. As a consequence, this book focuses on the question of how to organize and manage *evolving* pattern libraries within and across such collaborative projects.

In this regard, the book contains several important contributions. The first one is the systematic and empirically based gap analysis with respect to existing solutions, combined with a careful definition of requirements in terms of knowledge sources, incentive mechanisms, and structures.

The second contribution is the conceptual and technical design of the Evolving Pattern Library (EPL) environment, using a well-designed, iterative, practice-driven methodology. Context adaptation to different roles, tasks, and situations in these knowledge-consuming and knowledge-producing projects are important aspects of visualizing the EPL.

The third important contribution is a major empirical validation of the approach in the application domain of emergency management, which is rather typical for this novel class of human-centric cyber-physical systems. From the scientific viewpoint, this serves as an initial validation that the EPL actually works. For a reader from practice, the case study can serve as a role model for transferring the ideas in this book into their own system challenge.

The book should thus be of great interest to researchers, developers, and project managers in the field of engineering complex networked and embedded systems in innovative application domains, e.g. in sectors such as emergency management, energy management, or adaptive production systems. It was successfully defended as a doctoral thesis in the Computer Science Department of RWTH Aachen University in the fall of 2013.
Enjoy reading it!

Aachen, March 2014

Prof. Dr. Matthias Jarke

Institute Director, Fraunhofer FIT

Die Institute des Fraunhofer-Verbunds Informations- und Kommunikationstechnik (IuK) entwickeln gemeinsame Strategien für die anwendungsorientierte Forschung.
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An Evolving Pattern Library for Collaborative Project Documentation

Von der Fakultät für Mathematik, Informatik und Naturwissenschaften der RWTH Aachen University zur Erlangung des akademischen Grades eines Doktors der Naturwissenschaften genehmigte Dissertation

vorgelegt von

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Prof. Dr. Uwe Zdun

Tag der mündlichen Prüfung: 11. Dezember 2013

Diese Dissertation ist auf den Internetseiten der Hochschulbibliothek verfügbar.

Fraunhofer Series in Information and Communication Technology

Band 1/2014

René Reiners

An Evolving Pattern Library for Collaborative Project Documentation

Shaker Verlag
Aachen 2014

Bibliographic information published by the Deutsche Nationalbibliothek
The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.d-nb.de.

Zugl.: D 82 (Diss. RWTH Aachen University, 2013)

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Printed in Germany.

ISBN 978-3-8440-2797-6
ISSN 1612-4863

Shaker Verlag GmbH • P.O. BOX 101818 • D-52018 Aachen
Phone: 0049/2407/9596-0 • Telefax: 0049/2407/9596-9
Internet: www.shaker.de • e-mail: info@shaker.de

Abstract

In distributed research projects, the involved personnel acquires lots of technical and domain-specific knowledge. Generalizable outcomes of single project partners that are relevant to all stakeholders need to be distributed within the project. Since the involved parties may possess very different professional backgrounds, specific jargon and different ways to document results may lead to inefficient exchange. Therefore, within this kind of projects, it is a hard task to communicate and keep general project knowledge current. It is likewise difficult to provide achieved results for future projects.

This thesis proposes to collaboratively describe project outcomes and gathered domain knowledge as evolving design patterns. A design pattern must, by definition, be easy to read and understand by non-experts. This enables all stakeholders to apply the described contents without requiring specific background knowledge. The thesis develops a collaborative pattern formulation and validation process that takes into account the special conditions of joint research projects. Therewith, the research and development personnel can easily draft project knowledge in parallel to their efforts as initial design patterns that are refined over time.

From initial ideas or open problems the formulations evolve to validated and reusable patterns that are organized within a dynamically growing pattern library structure. A lightweight role model supports composing new and reviewing existing submissions as well as administrating the library structure. The derived maturation process ensures the formulation quality of the pattern by reflecting the proposals and opinions of all participants. In addition, all contributors collect evidence to support or refute the solutions suggested by a pattern. The research methodology included, besides research in literature, user-centered, iterative design methods that involve representatives of the research and development personnel.

The approach was concretely implemented within a customizable technical platform and substantially validated in an existing distributed research project. A second study was conducted in an academic context in which patterns are used to incrementally document findings. These validations indicate that the evolving pattern library concept is understandable and achieves high acceptance. Furthermore, it can be a useful tool for improving knowledge exchange and accumulation within and across projects.

Zusammenfassung

Innerhalb verteilter Verbundprojekte erwirbt das beteiligte Personal eine große Menge an technischem und domänenspezifischem Wissen. Verallgemeinerbare Ergebnisse einzelner Projektpartner die für alle Interessensvertreter von Bedeutung sind, müssen innerhalb des Projektes zugänglich gemacht werden. Da die beteiligten Parteien zumeist über sehr unterschiedliche fachliche Hintergründe verfügen, können verwendetes Fachvokabular und verschiedene Arten der Ergebnisdokumentation zu ineffizientem Austausch führen. Deshalb ist es mühsam, allgemeines Projektwissen innerhalb dieser Art von Projekten zu kommunizieren und aktuell zu halten. Es ist ebenfalls schwierig, erreichte Ergebnisse für zukünftige Projekte bereitzustellen.

Der Ansatz dieser Arbeit besteht darin, Projektergebnisse sowie gesammelte Erkenntnisse über die Anwendungsdomäne gemeinsam als sich entwickelnde Entwurfsmuster zu beschreiben. Ein Entwurfsmuster muss per Definition für Nicht-Experten einfach verständlich sein. Dies ermöglicht allen Interessensvertretern, die beschriebenen Konzepte ohne Spezialwissen zu verwenden. Die vorliegende Arbeit entwickelt einen gemeinsamen Prozess zur Formulierung und Validierung von Entwurfsmustern, der die besonderen Bedingungen von Verbundprojekten berücksichtigt. Somit kann das Forschungs- und Entwicklungspersonal Projektwissen auf einfache Art parallel zur Projektarbeit als anfängliche Entwurfsmuster skizzieren und über die Zeit verfeinern.

Von anfänglichen Ideen oder offenen Problemen entwickeln sich die Formulierungen zu validierten und wiederverwendbaren Entwurfsmustern, die innerhalb einer dynamisch wachsenden Entwurfsmuster-Bibliothek organisiert werden. Ein einfaches Rollenmodell unterstützt das Verfassen neuer und die Überprüfung bestehender Beiträge sowie die Administration der Bibliotheksstruktur. Der hergeleitete Reifeprozess stellt die Formulierungsqualität der Entwurfsmuster sicher, indem die Vorschläge und Meinungen aller Teilnehmer reflektiert werden. Weiterhin sammeln die Benutzer Beweise, um die innerhalb eines Entwurfsmusters vorgeschlagene Lösung zu unterstützen oder zu widerlegen. Die durchgeführten Forschungsarbeiten zur Erlangung der präsentierten Lösung beruhen, neben einer Literaturrecherche, auf einer nutzerzentrierten und iterativen Entwicklungsmethodik, die Vertreter des Forschungs- und Entwicklungspersonals miteinbezieht.

Der Ansatz wurde konkret mit Hilfe einer anpassbaren technischen Plattform realisiert und in einer umfangreichen Studie im Rahmen eines existierenden verteilten Verbundprojektes validiert. Eine zweite Studie wurde in einem akademischen Kontext durchgeführt, in dem Entwurfsmuster dazu verwendet wurden, Ergebnisse schrittweise zu dokumentieren. Diese Validierungen zeigen, dass das Konzept einer sich entwickelnden Entwurfsmusterbibliothek verständlich ist und hohe Akzeptanz findet. Darüber hinaus stellt es ein praktisch nutzbares Werkzeug dar, um den Wissenstransfer und -aufbau innerhalb und zwischen Projekten zu verbessern.

Acknowledgements

As a matter of course, this dissertation was compiled solely. However, the derivation of its topic and the engineered results were performed similarly to the described pattern formulation process, i.e. based on collaboration, iterative refinement and incorporation of feedback from discussions.

First of all, I would like to thank my advisor, Prof. Dr. Matthias Jarke, for accompanying my research work, especially in the final phase of this thesis.

Thanks also go to Prof. Dr. Uwe Zdun for taking over the role as co-advisor and the helpful discussions throughout the PLoP 2012 and EuroPLoP 2013 conferences.

My colleagues at the Fraunhofer Institute for Applied Information Technology FIT continuously helped me during my research efforts to keep motivation and confidence. In this regard, great thanks go to the whole *User-Centered Ubiquitous Computing Group*. All of you were of great support and represent a team one may often only hope for.

I would like to emphasize my gratitude towards the head of our group, Dr. Markus Eisenhauer, who constantly supported me by making it possible to integrate my dissertation into our daily work. Thanks also go to Dr. Andreas Zimmermann who helped structuring my thoughts during the focusing phase of the dissertation concept.

A team also changes over time. Therefore, I would like to take the chance to say thank you to our former head of our department, Prof. Dr. Reinhard Oppermann for his support and encouragement that "it will work out". His feedback during presentations and discussions helped to shape the frame for the work as it shows now.

The final phase of this work was written in solitude, meaning that I had to give up an excellent daily work environment from my first day at Fraunhofer FIT. My former colleague, Dr. Christian Prause, who changed position, always was a patient discussion partner and good friend during work and beyond.

The latter is to be said in particular about my colleagues Marco Jahn, Uwe Kirschenmann and Mark Vinkovits who constantly monitored my physical and psychological condition. They always made sure that I remained trained and reduced stress on our workout device situated in our premises.

Not to forget the good spirit of our group: Andrea Bernards who has always been able to talk to me about life besides computer-science and always helped me to survive the organizational demands appearing throughout our daily business.

Beyond our group's borders, Prof. Dr. Wolfgang Prinz always showed interest in exchanging knowledge and supported offered master thesis. Judith Flory provided important feedback from another, non-computer-scientific perspective.

Valuable expert and user feedback was gathered during the workshops and case studies conducted in the scope of the BRIDGE project and the ARL Summer School event. Thanks to all 50 participants of the workshops! I apologize for not listing you all at this point. The same is to be said about the participants and shepherds of the writers' workshops at the PLoP 2012 and EuroPLoP 2013 conferences.

Regarding the BRIDGE project, special thanks go to the supporters of the developed approach from the very first minute, Ragnhild Halvorsrud, Aslak Wegner-Eide, Daniela Pohl, Monika Büscher and Marc Jentsch. Common discussions and publications always were a pleasure. I could rely on their support at any time.

From the common efforts for the ARL workshops, I got to know a very friendly research group at Reutlingen University, Germany. Prof. Dr. Alfred Zimmermann and his team, especially Michael Falkenthal, always provided oportunities for discussion and experimentation. Thanks to their interest, the approach could be further developed.

My family and friends continuously reminded me that there is still life besides work. They showed understanding and gave me support all the time. Special thanks at this point go to my best friend and best man Sebastian Kayser. Despite some distance, he always managed to keep our friendship alive across geographical borders.

My parents, Renate and Heinz-Willy Reiners, never doubted that the day of completing this thesis would come. They always had the energy to support and encourage me, even in situations that demanded their full power. Ursula and Matthias Komischke, my parents-in-law, equally gave me moral strength and always provided an agreeable environment since I know them. Thanks also go to Simone Komischke and Henning Pillekamp who always provided nice distractions by organizing parties or simply changing their accomodation.

Finally, I would like to dedicate this work to the person that had to endure my moods during all the time and never got tired of proof-reading all these texts:

My beloved wife, Beatrice Reiners.

If there is a pattern for becoming happy in life, then you are the proven solution.

René Reiners

in December 2013

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