MERLIN COLLABORATION HANDBOOK
Challenges and Solutions in Global Collaborative Product Development

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Abstract: Global, collaborative and distributed development is increasingly common in software development. However, the traditional product and software development technologies do not support this way of working well, e.g., time and cultural differences cause new requirements for these technologies. In this paper, we introduce a public web-based handbook, collecting the challenges encountered in global collaborative development by the companies, and also a large number of solutions that help in tackling these challenges. The handbook was implemented using an ontology editor and generating HTML pages. In the final phase of the development the handbook was validated by several external testers, with main feedback being that the handbook was found useful, but more practical solutions would be welcome. Handbook was also updated based on the feedback.

1 INTRODUCTION

In the perspective of growing size and complexity of embedded systems, companies are not able to develop all the required functionality by themselves. As a result, suppliers specialize in specific functionality or specific skills which they can sell to others. This is clearly visible in the growing numbers of the outsourcing constructions in the past years. For example, a survey (VA Software, 2005) found that 74% of the participated companies had more than one development location. 48% had four or more locations and 26 % had more than 20 locations. Furthermore, a major survey carried out by the Software & Information Industry Association (in January 2007) indicates that companies are increasing their global development efforts: 57% of the survey participants have significantly increased offshore work in the past 18 months and many plan to add still more in the next 18 months. Growth strategy was cited as an important or critical driver for 84% of respondents, while increasing speed to market and productivity were the next most important drivers. Collaborative engineering of embedded systems has become a fact of life, and currently there is no way back anymore; companies have already outsourced large parts of their developments to other companies, resulting in no longer having the related skills available in their own organisations. Instead, the companies need to manage a complex situation of many partners, sub-contractors, suppliers, software platforms and so on. Practice has shown that the traditional single company development technologies do not support collaborative product development well. For example, another survey shows that 80% of companies are unsatisfied with their overall collaborative development efforts. Survey respondents expressed as main problems the poor foundation for collaboration and poor management of partner relationships. These problems are often caused by, e.g., time difference and geographical distribution that cause new requirements to the ways of working and tools. Also, understanding each other is not straightforward due to different backgrounds, e.g., different terminologies, cultures etc. but needs to be supported by technologies.

There are some experience reports about challenges companies have faced in collaboration, for example, Philips (Kommeren et al., 2007), Siemens (Bass and Paulish, 2004), Motorola (Battin et al., 2001), Alcatel (Ebert and Neve, 2001), and Lucent Technologies (Herbsled et al., 2003). Also several books that are discussing the problematics in collaboration and solutions to address them have been published (Karolak, 1998), (Carmel, 2005), (Sahay et al., 2004), (Carmel and Tija, 2005), (Damian, 2007). There are also conferences and

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workshops such as ICGSE (International Conference on Global Software Engineering) dedicated to global software engineering. However, these sources cover only some viewpoints of collaborative software development and until now no comprehensive collection of challenges and solutions for product development in collaboration could be found. Still, all these sources have been used as input for the Merlin Collaboration Handbook.

In this paper collaboration means that two or more entities work together to create mutual value. These entities can be companies, departments or even teams and they can combine in any one of several different business relationships and for very different periods of time. Importantly, the entities are physically in different locations, i.e., the development is distributed.

This paper is organized as follows: first, in chapter 2 we discuss the process of writing the handbook. Next we present the contents of the handbook in general level, including the structure and technical implementation of the handbook in chapter 3. In chapter 4 we discuss the validation of the handbook and end the paper with some conclusions and thoughts for further work.

2 MERLIN HANDBOOK DEVELOPMENT

The purpose of the handbook - defined in co-operation with the Merlin project consortium - is to support operational collaborative development, i.e., help companies to take care of all critical aspects during various phases of the collaborative project. In practice this would be done by collecting, listing and structuring these critical aspects as well as ways to address them, called solutions into a handbook. Furthermore, in order to make the handbook usable, ways to access parts of the contents based on user's interests should be made easy.

The building of the handbook started by defining it's structure; an initial framework for the structure of the handbook was derived from literature. CMMI (CMMI, 2006) was used as the basic structure due to its wide acceptance in software world and challenges reported by others grouped according to the CMMI structure. Based on the initial framework an industrial inventory was carried out, including interviewing the industrial partners of the Merlin project. These interviews lead to many refinements to the framework, especially in the details, although several of the challenges encountered by the interviewed companies were also mentioned in literature. We have discussed these differences in (Hyysalo et al., 2006), main being that the approaches represented by literature, on one hand, and industrial practitioners, on the other, towards problems related to collaborative work are different. The industry emphasizes technical aspects and detailed problems concerning engineering practices, while the literature focuses on solutions for more general issues like communication and team building. We found plenty of solutions for management and support practices in the literature but only few solutions for engineering practices. Thus, in order to provide more content to the handbook, collection of best practices from Merlin industrial partners was also done via focused interviews on selected topics. Results of these focused interviews were then included as solutions and experiences related to them in the handbook. Finally, also the research and development work done during the Merlin project was added to the handbook as solutions.

In order to support usability, e.g., the different views, and due to very large amount of content, the handbook was not implemented as a physical book, but a structured documentation solution was used to support readability. Implementation is discussed in more detail in section 3.3.

In practice, the handbook was developed in bi-monthly workshops with the Merlin consortium to refine implementation and contents of the handbook based on prototypes. The workshops had also representatives with experience on such repositories and usability, for example. Also, in the last phase of the project, the Handbook was validated by 16 external testers (this is discussed more in section 4).

3 HANDBOOK CONTENTS

This section describes the contents of the handbook in general level. The complete handbook is available in the internet (http://www.merlinhandbook.org).

3.1 Structure

The handbook structure is presented in the following Figure 1.The handbook structure is formed using topics; three main topics, namely management, engineering and support practices and 21 subtopics, such as collaboration management, requirements definition, testing, configuration management, and co-operative work.

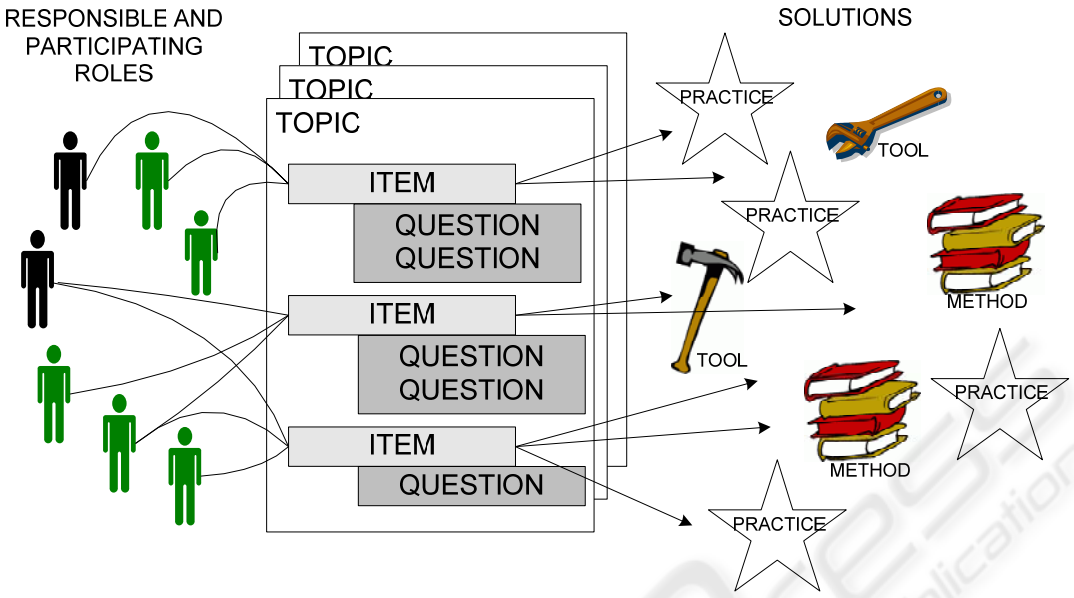

Figure 1: Merlin collaboration handbook structure.

Each subtopic has number of important items, altogether about 80 of them, such as product roadmapping, conditions for collaboration, practices for resolution of conflicting requirements, sharing of test cases, unified CM practices, cultural differences, etc.

Items are then still refined to questions, that further detail the item. For example, “Are supplier agreements and long-term framework agreements used as input for roadmapping?” is a question under “product roadmapping” item. The challenges faced by industry are especially visible in the items and questions of the handbook; they were first gathered in the industrial inventory and critically refined during the handbook development. The topics are mainly general, following CMMI structure to a large degree and the collaboration specific issues are visible in the item, question and solution level; we included only items, that are either specific for collaborative development or as in most cases are more difficult and complex to manage in collaborative situation.

In addition to topics, items and questions, also roles are defined. There are both responsible role and main participating roles defined for each item. The roles include all common product development roles, for example, senior manager, project manager, chief architect, etc. By roles, a checklist of questions the role is responsible for can be retrieved from the handbook. For example, Table 1 shows the checklist for the role Quality manager.

For each item also solutions are included in the handbook. Solutions are methods, techniques, tools, and practices that help in taking care of important items and they are classified according to their level of validation:

- Academic case, meaning that the solution is proposed in literature, often with academic case studies. These types of solutions were included also to provide ideas for items that were not so well covered with industrially proven solutions.
- Industrial case, meaning that the solution is proposed in literature or developed in Merlin with industrial case studies.
- Legislation or standards.

Each solution has also a standard description including ID, name, summary, description, evidence of suitability (level of validation), type of solution, collaboration dimensions, and references to further information.

3.2 Example of Contents

An example of contents of the handbook is requirements engineering. In the handbook requirement engineering is divided to two topics, requirements development and requirements management. Requirements development has eight important items and requirement management has three important items defined in the handbook.

Table 1: Quality manager's checklist.

A. Management practices	
Are relationships between common quality management process and partners own quality practices defined?	Responsible
Does the contracting process take into account all involved parties or stakeholders and do they have the required power of authority or signing?	Participates
Are suppliers or customers co-operation capability analysed beforehand?	Participates
Are the partners processes and quality management system of enough maturity?	Participates
B. Engineering practices	
Are the costs for non-quality taken into account while releasing the product. Have the costs for non-quality of the various suppliers been estimated?	Participates
Are performed tests and test results communication practices between partners defined and followed?	Participates
Are practices for incorporating feedback from customers to requirements development process defined and working?	Participates
Have the results of acceptance testing been taken adequately into account?	Participates
C. Support practices	
Is common process across sites or partners as thin as possible and forced as little as possible?	Responsible
Is the in-house review process defined and followed by each partner?	Responsible
Are best practices recoded and used between partners?	Responsible
Are common practices for quality assurance defined?	Responsible
Is shared process improvement work defined and agreed upon in long term relationships?	Responsible
Are common templates defined and used where applicable?	Participates
Is the effectiveness of collaboration evaluated for example as part of end-of-project evaluations?	Participates

An example of important item for requirements development is "Clear prioritization rules and practices / trade-off of the requirements". This item has five solutions in the handbook that help taking care of priorisation. These solutions are methods that base on giving values to different requirements (pairwise comparisons, e.g. AHP), negotiation approaches that base on the idea that the priority is determined by reaching agreement between the different stakeholders and dedicated requirements priorisation methods and techniques specifically supporting collaboration.

Another example of topic is collaboration management. For this topic nine important items have been defined, including for example, "establishing / evaluating conditions for collaboration" and "clear agreements with suppliers". The latter has four solutions, e.g., guidelines for acceptance criteria definition and creating a contract.

3.3 Technical Implementation

Handbook data is stored and managed using Protégé. In general, Protégé is an open platform tool for ontology modelling and knowledge acquisition framework (Protégé Web Pages). It offers a way to manage the cross-references in a mass of textual data in a RDF/OWL format (RDF Pages). There are predefined ontologies available on the web, which can be imported into Protégé and can then be used as a basis for other ontologies.

To develop the Handbook with Protégé, a data model of the Handbook was created. This was done by studying the structure of the Handbook (practices, topics, etc.), their relationships and the requirements for categorizing scopes. According to this study, the data model was designed. A decision was made to use the owl: Tool -ontology as a basis for the Handbook ontology. The Tool -ontology was chosen because it's content and link structure closely resembled that of the handbook. The Tool -ontology was then modified to reflect the Handbook data model. When the structure was finalised, the instances, that is, the content of the Handbook with their relationship information, was inserted into the ontology.

In order to be able to represent the Handbook data in web format, conversion from OWL/RDF format into something more suitable for our purposes was needed. This was done by using Protégé's possibility to extend its functionality via plugins. A special purpose plugin was written which exports the OWL/RDF information into easily usable XML format. In the new format the data is structured as a tree, that is, on top there is a practice with its attributes, a practice has items with their own attributes and so on.

The next challenge was how to represent the information to users via web interface. Major requirement specified for the HTML Handbook was to have a possibility to scope the content according to user specifications in order to offer different views into the contents.

Scoped view into handbook was achieved by defining scoping parameters which can be used to bring out the different views. When entering the handbook, the user is first presented with a form in

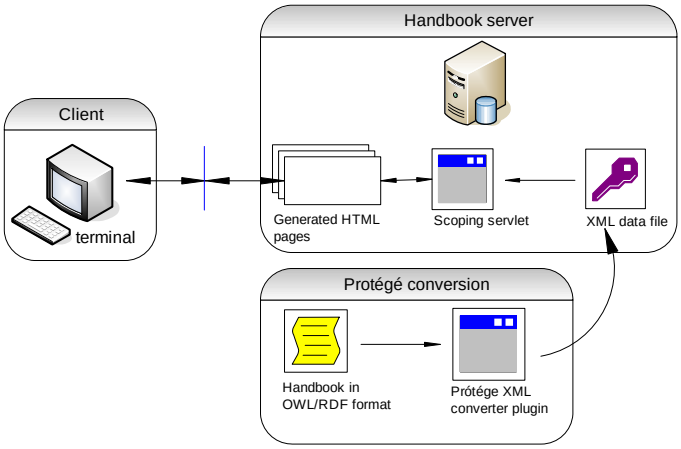

Figure 2: Merlin Handbook data flow.

which he/she can tick suitable parameters to trigger the scoping process. Consequently, the same parameters are inserted in the Handbook ontology as attributes. These attributes make it possible to scope the content by using the XML data file generated by the Protégé converter and the Java servlets which ultimately render the selected content for the user. The following Figure 2 illustrates how handbook operates.

This approach makes the handbook content management simple; after the updated content has been defined in Protégé, it is only necessary to run the converter plugin and to deploy the new XML file to handbook web pages. This solution also guarantees that all the web pages have uniform layout.

From the usability point of view the scoping alone was not enough for navigating the handbook data. Therefore the handbook offers a search mechanism for its users by the means of Apache Lucene search-engine. Lucene offers many powerful features, most notable being the offline indexing support. Initially several other search engines were tested, but these were deemed too slow, mainly because they lacked the offline indexing feature and instead relied on to dynamical crawling. Because Lucene is available as open source it could be easily modifed to support the special features of handbook, namely the scoping.

The handbook was developed iteratively; bi-monthly workshops were arranged where the development versions of the handbook were presented to project members. Most of the feedback received from these sessions were improvements to the user interface (UI) and general usability, but also the scoping mechanism was defined in the workshops. These workshops were found to be especially important for the developers so they could see they were on the right track and could receive further guidance when needed. Also, they provided the project members continuous updates to current situation and opportunities to influence the Handbook.

4 HANDBOOK VALIDATION

During the project, the handbook was validated in two different ways in addition to the workshops that gave continuous feedback for the development. Firstly, 16 external testers used the handbook and provided feedback and secondly the handbook was used in an industrial case to support improving subcontracting efficiency in a company. Both of these are discussed in this chapter.

4.1 External Testers

In the final phase of the Merlin project, the handbook was tried out by external testers. These testers were found by asking the Merlin industrial partners to find persons in their organizations that have not been involved in the Merlin project but who are knowledgeable in the topic, i.e., collaborative product development. Another source for these external testers was the public seminars, where the handbook prototypes were presented and volunteers for testing asked for. The users were typically project managers that had experience in collaborative projects and altogether 16 external users were granted access to the handbook during development.

During the validation, the external users were asked to think of a typical problem they would have

in collaborative product development and try to find answers and help from the handbook to address this topic. No further instructions on using the handbook were given at first. Also, the feedback was to be given in free format including the chosen problem and the findings and other comments.

Feedback from the external users related mainly to the usability or the content of the handbook. Based on the testers' experiences, the handbook looked nice and worked fine. Also, one of the testers noted that handbook had very clear page lay-out. However, some handbook mechanisms needed explanations or guidelines for use. For instance scope selection page was not self-explanatory (e.g., what was meant by item, type of source, agreement base, etc.). Also, bookmark mechanism was not explained, thus it was not clear where the bookmarks were accessible.

The comments to the content of the handbook, related to new solutions that should be added to handbook. As one of the testers reported, on many problem area's underlying documentation was not yet given. Thus, it was suggested that following information should be added to the handbook: reporting practices, multi-site peer reviews, selecting configuration management tools, interactive process model based on best practices, and data on measurements. Also, one of the testers reported that the handbook included too little information on measurements, metrics, reporting and follow-up in both management and project management. It was also requested that the handbook should answer to following questions: what are readiness assessments or checklists for collaboration, and why to work collaboratively?

Furthermore, according to one of the testers, the overall information in the handbook tended to be quite theoretical. Hence, for practitioners, practical or implementation examples were missing, meaning that findings remained abstract and theoretical. Some guidelines were provided in the handbook, but it could not be found how to do that in practice. It was also pointed out by another tester that the usage of proven practices was a good idea, since a larger number of examples would bring additional value to the handbook.

It was also pointed out by one of the tester's that references to Google and Scholar Google sites should be improved, e.g., to include the key words of the specific publication in the URL, so that the users wouldn't have to retype the words themselves. It was also noticed that common terminology for the handbook should be provided in order to avoid inconsistency of the terms used in the handbook.

Based on these comments by external testers, handbook usability and content has been improved. Now, the handbook is faster and easier to use. For instance, help texts and terminology have been added to the handbook in order to facilitate the use. Also, information is much easier to find, then before the users comments, since scoping and search operations have been added to the handbook. With the scoping operation, the content of the handbook can be shown based on user's needs and situations and with the search operation specific topics, items or solutions can be easily found from the handbook. Also, based on the external testers' comments and wishes, the content of the handbook has been improved, for instance, new solutions have been created. User experiences also affected to the content of the solutions, e.g., what attributes (i.e. geographical distance, cultural differences, time difference, etc.) are taken into account in the solutions. Also, solutions' references have been updated. Furthermore, at the end of Merlin project, all results from the project have been written in solution format, so that the content of the handbook would be more extensive and to include more experience-based solutions than before, as the users requested.

4.2 Industrial Case

The Merlin Handbook was used to first analyse and then to improve the subcontracting practices of a company participating in the Merlin project. The aim of the case was specifically to improve controllability and efficiency of the subcontracting. The Handbook structure of items and questions was used as interview framework to find out the strengths and weaknesses of the current practices. This resulted in several improvement areas for the current practices but also to some additions to the Handbook items, as some challenges identified were not yet included in the Handbook. Then the handbook was used to find solutions to the improvement areas. Several solutions were found and were then applied to the company's needs.

The Handbook helped especially in gaining confidence to change as the solutions and experiences presented in the handbook supported the company's own ideas. Use of handbook helped also in minimizing risks, as the handbook could help in providing proven guidelines that can then be applied to own situation. Also, instead of having to reinvent the wheel the knowledge gained by larger network of people could be utilized. That saved time, due to

avoiding using effort on basic issues and being able to focus on adapting proven solutions to own needs.

As a result, due to the improved, more effective practices, the number of the subcontracted personnel could be significantly increased, meaning that more work can now be subcontracted, freeing the company's own personnel to other tasks.

5 CONCLUSIONS AND FURTHER WORK

In this paper we have introduced a public web-based handbook, collecting the challenges encountered in global collaborative development by the companies, and also a large number of solutions that help in tackling these challenges. The handbook was implemented using an ontology editor and generating HTML pages. In the final phase of the development the handbook was validated by several external testers, with main feedback being that the handbook was found useful, but more practical solutions would be welcome. Handbook was also updated based on the feedback. The Handbook was also found useful in improving a company's subcontracting practices, especially as it provided confidence to change.

The handbook is a collection of both literature and industrial experience. Especially the structure of the handbook, the topics, items and questions are based on challenges faced by industry. We have then made a collection of available solutions to these challenges and provided sources for further information. Many of the solutions are based on industrial experience, however, this is always situation dependent and it is up to the user to consider the usefulness of the solution to his/her situation. Also, the topic and different usage situations to be covered by the handbook is very large. Thus, we realize we could not cover everything during this three year project. However, based on the feedback from the users of the handbook so far, we can say that the handbook is helpful for a company working in collaboration with others; it can at least give ideas and triggers to consider while doing the work, and even provide complete, validated solutions to tackle the faced challenges.

In order to further advance the handbook, we have included an opportunity in the handbook to add new solutions by the users. However, these new solutions will first be reviewed by the Merlin project partners before they are accepted to the handbook. We also welcome other feedback. The handbook is publicly available from http://www.merlinhandbook.org.

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