

A SYSTEMATIC LITERATURE REVIEW OF REQUIREMENTS ENGINEERING IN DISTRIBUTED SOFTWARE DEVELOPMENT ENVIRONMENTS

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Abstract: On analyzing the main characteristics of Distributed Software Development (DSD) phenomenon, we can notice that they particularly affect Requirements Engineering (RE). With the evolution of this phenomenon, the result is an increasing in the existent literature. For this reason, in this paper we report from a systematic review of the DSD literature, where we looked for challenges and possible solutions related to RE in DSD environments. We also discuss gaps of this research area, which can be used to guide future researches.

1 INTRODUCTION

Distributed software development (DSD) is becoming the norm for today's software projects. Its characteristics (physical and temporal distance, cultural and language differences), affect activities that require constant communication and cooperation, like Requirements Engineering (RE).

On perceiving (i) the growth of the DSD; (ii) the increasing of studies about this phenomenon; (iii) the heterogeneous literature about this research area (Prikladnicki et al, 2008); and (iv) the relevance of RE for DSD environments; the goal of this paper is to report from a Systematic Literature Review (SLR) of RE in DSD environments. Our contribution relies on the categorization of the studies found and identification of the challenges and solutions. In the next Section we present the details of our SLR; in Section 3 we present the main challenges and existing solutions found; and in Section 4 we conclude the paper.

2 LITERATURE REVIEW

A systematic literature review helps to identify and interpret relevant studies for a specific question. Our SLR follows the recommendations provided by Biolchini et al (2005) and Kitchenham (2004) and was executed between April and June of 2008.

Research Questions. The main purpose of our SLR was to find existing studies that propose or explore challenges and solutions of RE in DSD environments, identifying possible gaps in the research area. The following research questions were defined:

Research Question 1: Which are the main difficulties and challenges of DSD environments, in respect to RE?

Research Question 2: Which are the available methods, models, techniques and approaches to RE in DSD environments?

Research Question 3: Which are the available tools to support RE in DSD environments?

Sources Selection. We searched digital libraries such as ACM Digital Library, IEEEExplore, SpringerLink and ScienceDirect. The search strings were defined using logical expressions, keywords and synonymous based on the research questions.

Studies Selection. We searched for studies in English and ranging from the year 2000 to 2008. We read the title and abstract from the papers found, excluding those not related to the research questions.

Information Extraction. We have conducted both quantitative (Table 1) and qualitative (Section 3) analyses of the selected papers. The type of study was defined according to Neto et al (2007) and the DSD Model was defined according to Prikladnicki et al (2007).

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Table 1: Quantitative Analysis.

Challenges	References	Type of study	Empirical focus	DSD Model
Method, Model, Technique, Approach				
Communication issues	(Damian et al 2006)	Empirical	Validation	Offshore outsourcing
	(Mikulovic and Heiss, 2006)	Industrial Experience	Proposal	Not Defined
	(Aranda et al, 2006)	Empirical	Proposal	Not Defined
	(Korkala and Abrahamsson, 2007)	Empirical	Proposal	Not Defined
	(Layman et al, 2006)	Empirical	Proposal	Offshore
Lack of common understanding of requirements	(Heindl and Biffl, 2006)	Empirical	Proposal	Offshore insourcing
	(Berenbach and Gall, 2006)	Empirical	Proposal	Offshore outsourcing
Lack of collaboration	X	X	X	X
Lack of common goals	X	X	X	X
National and organizational cultural differences	X	X	X	X
Change Management issues	X	X	X	X
Knowledge Management issues	X	X	X	X
Lack of efficient tools and techniques	(Lloyd et al, 2002)	Experimental	Proposal	Not Defined
Tools				
Knowledge Management issues	(Cubranic et al, 2004)	Empirical	Validation	Not Defined
Lack of common goals/National and organizational cultural differences	(Seyff et al, 2005)	Empirical	Validation	Not Defined
Lack of common understanding/Knowledge Management issues/Change Management issues /Communication issues/Lack of collaboration	(Sinha et al, 2006)	Empirical	Validation	Not Defined
Communication issues/Lack of collaboration	(Calefato and Lanubile, 2005)	Empirical	Validation	Not Defined
Result summarization: (i) there is a tendency for proposals related to communication problems (58%); (ii) most of the proposals are empirical studies (83%); (iii) all proposals used empirical focus, to propose or to validate the studies; (iv) most of the studies don't described the DSD model (66%); (v) several of the main challenges identified are not the focus of any method, model, technique or approach proposed.				
Total of methods, models, techniques and approaches: 8 – 67%; Total of tools: 4 – 33%; Total of proposals: 12 – 100%				

3 QUALITATIVE ANALYSIS

3.1 Challenges Identified

Communication Issues. Geographic dispersion makes it hard the communication about requirements and the lack of informal communication negatively impacts relationship building (Damian and Zowghi, 2002; Bhat et al, 2006; Damian, 2007). The time differences impact mainly the usage of synchronous and asynchronous communication tools (Berenbach, 2006). There is still a long way from understanding what media are suitable for the communication among distributed stakeholders (Herbsleb, 2007).

Lack of Common Understanding of Requirements. In DSD environments, the difficulties of achieving a common understanding about the requirements are amplified and much effort has to be spent on this task (Herbsleb 2007; Kommeren and Parviainen, 2007). Lack of common understanding only surface when they are expensive to fix (Sengupta et al, 2006) and can led to requirements misinterpretation, unshared information and difficulties on collaboration between stakeholders (Damian and Zowghi, 2002; Cheng and Atlee, 2007; Damian, 2007).

Lack of Collaboration. Lack of collaboration between distributed stakeholders happen due to differences in culture, language, distance and processes (Damian, 2007; Damian and Zowghi, 2002; Bhat et al, 2006).

Lack of Common Goals. In DSD environments, it's hard to establish common goals, due to the problems in communication and lack of common understanding (Bhat et al, 2006; Damian and Zowghi, 2002). This can cause different viewpoints and priorities on development process (Berenbach, 2006).

National and Organizational Cultural Differences. Cultural differences are the reason of the use of multiple RE processes and tools, causing problems, like rework, loss of data, difficulties to duplicate errors, confusion about how the work is done, etc. (Herbsleb, 2007; Berenbach, 2006; Damian, 2007; Bhat, et al, 2006). Differing attitudes and communication styles often result in stakeholders' misinterpretation and difficulties to understand the requirements (Damian, 2007; Damian and Zowghi, 2002; Herbsleb, 2007), particularly when they are from different organizations, with different work environments (Damian and Zowghi, 2002; Cheng and Atlee, 2007). The distributed requirements analysis is

particularly affected (Berenbach, 2006; Audy et al, 2004).

Change Management Issues. Change Management can be a daunting task in RE in DSD environments (Sengupta et al, 2006; Bhat et al, 2006), especially if there are not defined organizational policies for this (Berenbach, 2006). Kommeren and Parviainen (2007) said that changes in requirements increase the communication, which is a problematic issue. The distance between those originating requirements changes and those with decision-making, difficult this task (Damian, 2007). Jacobs et al (2005) noted a concentration of injection defects in the Requirements Specification phase, especially where changes are being handled.

Knowledge Management Issues. Requirements information was not appropriately shared with distributed stakeholders (Damian and Zowghi, 2002; Herbsleb, 2007), affecting the interaction between them (Damian, 2007).

Lack of Efficient Tools and Techniques. For DSD environments, Sengupta et al (2006) suggested the development of collaborative environments that encompass all phases of software development. Cheng and Atlee (2007) suggested new or extended RE techniques to support and to effectively manage distributed requirements.

3.2 Methods, Models, Techniques and Approaches Identified

Communication Issues. Mikulovic and Heiss (2006), Layman et al (2006) and also, Korkala and Abrahamsson (2007) suggest techniques to reduce the problems that can emerge in communication about requirements, such as: apply personal domain knowledge; define a person responsible for requirements specification and prioritization; use of direct communication channels between the developers, etc. Aranda et al (2006) proposed a method to select elicitation techniques and groupware tools, according to stakeholders' preferences and Damian et al (2006) argue that synchronous tools should be used for requirements negotiation and asynchronous tools are valuable to structure the discussions before these negotiations.

Lack of Common Understanding of Requirements. To increase the common understanding of requirements, Heindl and Biffel (2006) proposed a model that stores the relationship about the requirements and business goals and Berenbach and Gall (2006) proposed new UML

symbols and relationships to integrate functional, non-functional requirements and use cases.

Lack of Efficient Tools and Techniques. Lloyd et al (2002) argue that Question and Answer, Brainstorming, Requirements Management, and Use Cases are the most effective requirements elicitation techniques for DSD.

3.3 Tools Identified

Knowledge Management Issues. Cubranic et al (2004) proposed the Hipikat tool, which helps the distributed knowledge management, suggesting relevant artefacts (including requirements) to the developer tasks.

Lack of Common Goals/National and Organizational Cultural Differences. Seyff et al (2005) proposed the ARENA-M. This tool allows participating anywhere-anytime using mobile devices and supporting requirements elicitation performed directly in the work environment of future uses.

Communication Issues/Lack of Common Understanding of Requirements/Change Management Issues/Knowledge Management Issues. Sinha et al (2006) proposed the EGRET. This tool offers synchronous and asynchronous communication, storage of the conversations, change and knowledge management.

Communication Issues/Lack of Collaboration. Calefato and Lanubile (2005) suggested the eConference. This tool offers asynchronous communication, structured discussions, calendar and mechanisms for coordination and control.

4 CONCLUSIONS

#1: Tendency for Empirical Studies. In our SLR, most of the proposals were empirical (83%), corroborating with the findings of Prikladnicki et al (2008), where the authors also noted the tendency for empirical studies on DSD.

#2: Tendency for Studies with Empirical Focus. All the proposals were empirically based, proposing or validating something, which is good since it provides credibility to the proposals.

#3: Better Description of DSD Models. In our SLR, 66% of the proposals don't describe the DSD model, corroborating with Šmite et al (2008), where the authors argue that in order to understand the

applicability of the studies, the DDS scenario involved in the study shall be specified.

#4: Proposals Related to Communication. We found a tendency for proposals related to Communication (58%). Communication is crucial to the ER in DSD environments, like declared by several. However, we did not find proposals for other important challenges, which can be an idea for future investigation within this area.

REFERENCES

- Aranda, G. N., Cechich, A., Vizcaino, A., Piattini, M. and Castro-Schez, J. J. 2006. "Cognitive-based rules as a means to select suitable groupware tools". *In Int'l Conf on Cognitive Informatics*.
- Audy, J., Evaristo, R. and Watson-Manheim, M. B. 2004. "Distributed Analysis: The Last Frontier?". *In Int'l Conf on System Sciences*.
- Berenbach, B. 2006. "Impact of organizational Structure on Distributed Requirements Engineering Processes: Lessons Learned". *In Int'l Conf on Software Engineering*.
- Berenbach, B. and Gall, M. 2006. "Toward a Unified Model for Requirements Engineering". *In Int'l Conf on Global Software Engineering*.
- Bhat, J. M., Gupta, M. and Murthy, S. N. 2006. "Overcoming Requirements Engineering Challenges: Lessons from Offshore Outsourcing". *In IEEE Software*.
- Biolchini, J., Mian, P.G., Natali, A.C.C. and Travassos, G.H. 2005. "Systematic review in software engineering". *Technical report, Systems Engineering and Computer Science Department*.
- Calefato, F., and Lanubile, F. 2005. "Using The Econference Tool for Synchronous Distributed Requirements Workshops". *In Int'l Workshop on Distributed Software Development*.
- Cheng, B. H.C. and Atlee, J. M. 2007. "Research Directions in Requirements Engineering". *In Int'l Conf on Software Engineering*.
- Cubranic, D., Murphy, G. C., Booth, K. S. and Singer, J. 2004. "Learning from Project History: A Case Study for Software Development". *In ACM Conf on Computer Supported Cooperative Work*.
- Damian, D. 2007. "Stakeholders in Global Requirements Engineering: Lessons Learned from Practice". *In IEEE Software*.
- Damian, D. E. and Zowghi, D. 2002. "The impact of stakeholders' geographical distribution on managing requirements in a multi-site organization". *In Int'l Conf on Requirements Engineering*.
- Damian, D., Lanubile, F. and Mallardo, T. 2006. "The role of asynchronous discussions in increasing the effectiveness of remote synchronous requirements negotiations". *In Int'l Conf on Software Engineering*.
- Heindl, M. and Biffel, S. 2006. "Risk Management with Enhanced Tracing of Requirements Rationale in Highly Distributed Projects". *In Int'l Conf on Software Engineering*.
- Herbsleb, J. D. 2007. "Global Software Engineering: The Future of Socio-technical Coordination". *In Int'l Conf on Software Engineering*.
- Jacobs, J., Moll, J.V., Krausec, P., Kusters, R., Trienekens, J. and Brombacher, A. 2005. "Exploring defect causes in products developed by virtual teams". *In Information and Software Technology*.
- Kitchenham, B. 2004. "Procedures for Performing Systematic Reviews". *Technical Report SE0401, Keele University*.
- Kommeren R. and Parviainen, P. 2007. "Philips experiences in global distributed software development". *In Empirical Software Engineering*.
- Korkala, M. and Abrahamsson, P. 2007. "Communication in Distributed Agile Development: A Case Study". *In Conf on Software Engineering and Advanced Applications*.
- Layman, L., Williams, L., Damian, D. and Bures, H. 2006. "Essential communication practices for Extreme Programming in a global software development team". *In Information and Software Technology*.
- Lloyd, W. J., Rosson, M. B. and Arthur, J. D. 2002. "Effectiveness of Elicitation Techniques in Distributed Requirements Engineering". *In Int'l Conf on Requirements Engineering*.
- Mikulovic, V. and Heiss, M. 2006. "How do I know what I have to do? - The Role of the Inquiry Culture in Requirements Communication for Distributed Software Development Projects". *In Int'l Conf on Software Engineering*.
- Neto, A. C. D., Subramanyan, R., Vieira, M., Travassos, G. H. "Characterization of Model-based Software Testing Approaches". *In Technical Report TR – ES 713/07, COPPE/UFRI*.
- Prikladnicki, R., Audy, J. L. N., Damian, D., Oliveira, T. C., "Distributed Software Development: Practices and challenges in different business strategies of offshoring and onshoring". 2007. *In Int'l Conf on Global Software Engineering*.
- Prikladnicki, R.; Damian, D.; e Audy, J. L. N. 2008. "Patterns of Distributed Software Development Evolution: A systematic review of the literature". *In Int'l Conf on Evaluation and Assessment in Software Engineering*.
- Sengupta, B., Sinha, V. and Chandra, S. 2006. "A Research Agenda for Distributed Software Development". *In Int'l Conf on Software Engineering*.
- Seyff, N., Hoyer, C., Krother, E. and Grünbacher, P. 2005. "Enhancing GSS-based Requirements Negotiation with Distributed and Mobile Tools". *In Int'l Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprise*.
- Sinha, V. and Sengupta, B. 2006. "Enabling Collaboration in Distributed Requirements Management". *In IEEE Software*.
- Šmite, D., Wohlin, C., Feldt, R. and Gorschek, T. 2008. "Reporting Empirical Research in Global Software Engineering: a Classification Scheme". *In Int'l Conf on Global Software Engineering*.