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

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Keywords: Distributed Software Development, Requirements Engineering, Systematic Literature Review.

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, IEEExPlore, 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).
Table 1: Quantitative Analysis.

<table>
<thead>
<tr>
<th>Challenges</th>
<th>References</th>
<th>Type of study</th>
<th>Empirical focus</th>
<th>DSD Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication issues</td>
<td>(Mikulovic and Heiss, 2006)</td>
<td>Industrial</td>
<td>Proposal</td>
<td>Offshore outsourcing</td>
</tr>
<tr>
<td></td>
<td>(Korkala and Abrahams, 2007)</td>
<td>Empirical</td>
<td>Not Defined</td>
<td></td>
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<td></td>
<td>(Heindl and Biff, 2006)</td>
<td>Empirical</td>
<td>Proposal</td>
<td>Offshore insourcing</td>
</tr>
<tr>
<td></td>
<td>(Herbenbach and Gall, 2006)</td>
<td>Empirical</td>
<td>Proposal</td>
<td>Offshore outsourcing</td>
</tr>
<tr>
<td>Lack of common understanding of requirements</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Lack of collaboration</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Lack of common goals</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>National and organizational cultural differences</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Change Management issues</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Knowledge Management issues</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Lack of efficient tools and techniques</td>
<td>X</td>
<td>X</td>
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<td>X</td>
</tr>
</tbody>
</table>

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 effective 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 Biffl (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.

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