Requirements Management in Global Software Development: Preliminary Findings from a Case Study in a SW-CMM context

Rafael Prikladnicki, Jorge Audy, Roberto Evaristo
School of Computer Science, Pontifical Catholic University of Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil; University of Illinois, Chicago, United States
rprik@inf.pucrs.br, audy@inf.pucrs.br, evaristo@uic.edu

Abstract

The requirements analysis is an important phase in the software development process. In geographically distributed environments (Global Software Development), requirements management becomes critical due to the characteristics of the distributed development (physical distance, cultural differences, trust, communication, etc). The objective of this paper is to analyze the requirements management in geographically distributed environments, identifying the main challenges. The results are based on a case study carried in a multinational organization that has offshore software development centers in Brazil, India and Russia, and was recently certified in SW-CMM Model level 2 in the Brazilian unit. The results suggest the necessity to adapt the requirements management to the distributed software development environment, addressing the main existing challenges. The problems and the solutions adopted are presented, aiming to relate these solutions to the organization distribution level, considering the project team, users and customers.

1. Introduction

Software development has become part of the business globalization. This is mainly due the need for cost reduction, increased competitiveness and the possibility to share resources in a global scale [5]. As a consequence, the communication between the project team, users and customers occurs in a geographically distributed way. In this case, the requirements management seems to be an even more critical activity. Normally, the requirements' gathering occurs in meetings having all the participants (project team, users and customers) in the same place. This facilitates the communication, becoming easier any negotiation or existing conflict resolution. In the Software Engineering literature, software requirements represent the interests of customers and users and are the heart of any project [8]. The quality and the capacity of analyzing and managing the requirements of a software project not only affect the final product quality, but also the time necessary to satisfy the requirements. A badly managed requirement can mean a loss for the project and can compromise it success, generating delays or the cancellation of projects.

In distributed software development environments the challenges become even more significant. This paper has as objective to understand what kind of problems the project teams has faced when managing requirements in physically distributed environments and how these problems have been addressed. With this objective, a case study was conducted in a multinational organization with software development centers in Brazil, India and Russia, identifying the difficulties to analyze and to manage the requirements of a software project in this type of environment. The results are analyzed and the existing challenges are identified. Some of the solutions that are being implemented with the objective of minimizing the problems found are presented. Our contribution is in the identification of these problems and the addressing of the solutions. This paper has the following structure: section 2 presents the theoretical base; section 3 describes the research method; section 4 describes the case study; section 5 discuss the results found in the case study; section 6 presents the conclusions, future studies and the research limitations.

2. Theoretical Base

2.1. Requirements Management

Requirements engineering plays an important role in the software development. As said by [8], a requirement is the condition or capacity that a system that is being developed must satisfy. Therefore, the compliance with requirements determines the success or the failure of a project. The requirements are identified, registered, organized and verified during the project development. And that is what it called requirements management, a process that establishes and keeps the agreements firmed

between the project team, users and customers related to the changes of requirements in a specific system.

The literature states that the problems related with requirements engineering are one of the main reasons for software projects failures. This means that the final product does not have all the requirements gathering from users and customers [13]. Research identified that 70% of the requirements were difficult to identify and 54% were not clear and well organized. Also, it can be identified that [8]:

- Requirements are not easy to be described in words;
- There are different types of requirements in different levels of details;
- It can be impossible to manage the requirements if they cannot be controlled;
- Most requirements change during the project time.

Therefore, it is not difficult to find errors in the requirement specifications, and they can have a large impact in the project costs. An estimative shows that 40% of the requirements generate rework during the project life cycle [13]. It is evident that the earlier a problem is detected and solved (especially during the requirements phase), many other problems are minimized in the following project phases. But in contrast, what it is observed is a short time for the requirements phase in a project, not considering the project type or environment where this phase occurs.

2.2. Global Software Development (GSD)

As said by [9], software process is defined by a set of activities, methods, practices and technologies that people and companies use to develop and to keep related software and products. The interest in the software process is based on the following premises:

- The software quality is strongly dependent on the quality of the process used in its preparation;
- The software process can be defined, managed, measured and improved.

However, it is not a simple task to develop software using a well-defined development process. Such process has become increasingly more complex, whereas the software demands of companies increase according to the strategic importance for its operations.

As part of the globalization efforts currently pervading society, software project teams have also become geographically distributed on a worldwide scale. This characterizes Global Software Development (GSD).

Tools and technological environments have been developed over the last few years to help in the control and coordination of the development teams working in distributed environments. Many of these tools are focused in supporting procedures of formal communication such as automated document elaboration, processes and other non-interactive communication channels.

Moreover, [3], [4], [5] and [10] point out that GSD is one of the biggest business-oriented challenges that the current environment presents under the software development process point of view. Many companies are distributing its software development process in countries such as India, Russia and Brazil. Frequently this process occurs in only one country, particularly in regions with tax incentives or critical mass in some skill or resource areas.

Organizations search for competitive advantages in terms of cost, quality and flexibility in the area of software development [10], looking for productivity increases as well as risk dilution [7]. Many times the search for these competitive advantages forces organizations to search for external solutions in other countries (offshore outsourcing). This epitomizes the traditional problems and the existing challenges in GSD.

2.3. The Capability Maturity Model (CMM)

The Capability Maturity Model for Software (CMM or SW-CMM) has been developed by the software community with stewardship by the SEI (Software Engineering Institute). The first version was released in 1992 and describes the principles and practices underlying software process maturity and is intended to help software organizations improve the maturity of their software processes in terms of an evolutionary path from chaotic processes to mature, disciplined software processes. The CMM is organized into five maturity levels [6]:

1 - Initial: The software process is characterized as ad hoc. Few processes are defined, and success depends on individual effort and heroics;

2 - Repeatable: Basic project management processes are established to track cost, schedule, and functionality. The necessary process discipline is in place to repeat earlier successes on projects with similar applications;

3 - Defined: The software process is documented, standardized, and integrated into a standard software process for the organization for both management and engineering activities;

4 - Managed: Detailed measures of the software process and product quality are collected. Both the software process and products are quantitatively understood and controlled;

5 - Optimizing: Continuous process improvement is enabled by quantitative feedback from the process and from piloting innovative ideas and technologies.

Except for Level 1, each maturity level is decomposed into several key process areas that indicate the areas an organization should focus on to improve its process [6].

3. Research Method

This research is characterized as a study mostly exploratory, since the main research method was the case

study. It is possible to justify the use of qualitative methods since it involves the study of the system development process in its real context, with description and the understanding of the state of the art in those situations where practice precedes theory [12].

4. Case Study

4.1. Characterization of the Organization

The organization is a global software development center (GDC) located in Brazil, owned by a multinational organization with worldwide activities (one of the largest computer manufacturers in the world). This center was created in 2001 using incentives based on the Brazilian Law on Information Technology that stimulates companies located in the country to invest part of their earnings on research and development institutions providing tax exemption on manufactured products (IPI). The GDC aims to perform technological development for the organization in worldwide scope and since July of 2002 it is located inside of the technological park of a university in the South of Brazil. Many research projects are being developed, like the SW-CMM level 2 certification process monitoring and the study related to Global Software Development. All research projects are performed using both the organization professionals and the researchers and students of the host university.

Figure 1 shows the context of this study: the organization acts in global software development environment, having the Microsoft Solutions Framework (MSF) and the SW-CMM model as base for the software development processes definition. The Brazil GDC is a SW-CMM level 2 certified organization since January of 2003, with 2 years of work done to achieve this certification.

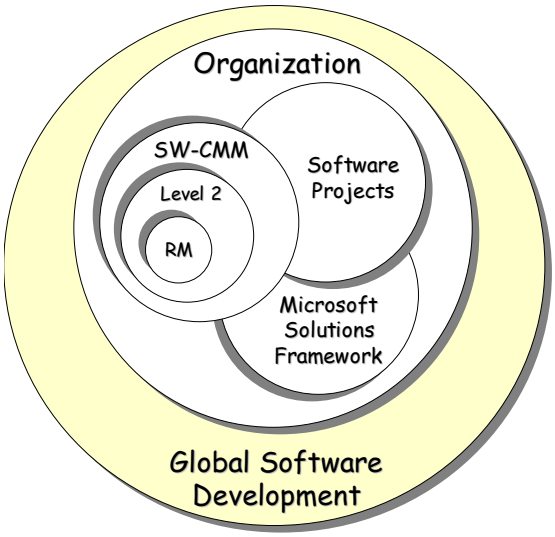

Figure 1. Organization context.

4.2. Defining the two projects evaluated

The objective of this case study is to analyze two projects developed in Brazil GDC, aiming at the identification of problems, advantages and disadvantages considering the requirements management (RM) in both projects in a geographically distributed context at the same time where the organization was working to obtain the SW-CMM level 2 certification. These projects were developed in the second semester of 2002.

Project 1: The objective of this project was to develop a new version of a tool related to employee compensation for the human resources area of the worldwide organization. This project lasted nine months. According the classification proposed by [11], the project team, customer and users had the following distributed level:

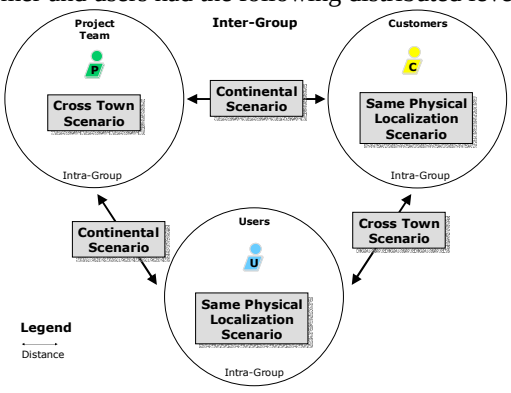

Figure 2. Project 1.

The three members of the project were located in different buildings of the Brazilian unit. The customers and users were located in the organization headquarters in the U.S., each one in its building.

Project 2: The objective of this project was to integrate and consolidate two versions (Latin American and Canadian) of an application of the manufacturing area into a single application. This project lasted one year. According the classification proposed by [11], the project team, customer and users had the following distributed level:

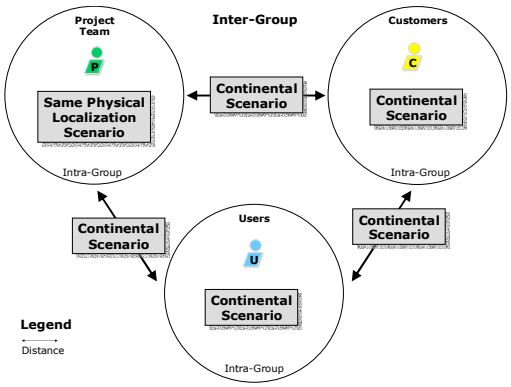

Figure 3. Project 2.

The project team had thirteen members and was located in the Brazilia unit, in the same physical space. The customer's team were distributed in a continental way, with members in Brazil, Mexico, Argentina, Canada and the U.S. The user's team were located in Latin America and Canada.

4.3. Case Study Results

During the project development, considering the requirements management, many observations were done and interviews with the Program Managers were performed. The results are presented below.

4.3.1. Project 1. The project was developed very well, even though there were both highlights and problems. Many solutions had been implemented in common agreement between the geographically distributed teams.

Considering just the geographic team distribution, the following issues were found:

Problems:

- Communication problems in the project beginning;
- Bad distribution of the activities between teams of Brazil and the U.S.;
- Bad planning in the beginning of the project;
- Inexistence of an evaluation of the impact that an activity would have for being done in a distributed way;
- Videoconference resources had not been used.

Highlights:

- The initial problems had motivated the definition of working standards;
- The distance facilitates the formalism;
- The Brazil team spent six weeks in the U.S. for the knowledge transfer process and to start the requirements gathering;
- The customer had visited Brazil to know the team and to approve the requirements specification document;
- Social programs had been done during the trips;
- Before the U.S. team came to Brazil, the Brazilian team finished all the pending activities aiming a good impression;
- The customer was not American and had already have problems related to cultural differences;
- A weekly meeting was performed with the customer.

Considering the implementation of the SW-CMM Model level 2, there was a great contribution of the certification process to the use of the requirements management process in a geographically distributed environment. The following issues were found:

Problems:

- The U.S. team was not involved in the certification process. Therefore, the Brazilian team had an additional task to explain why each activity was done that way.

Highlights:

- The implementation of process based on SW-CMM Model helped in the organization and standardization of the activities between the geographically distant teams;
- The director of the customer area in the U.S. gave total support in the understanding of the necessity to follow the process defined by the Brazilian team;
- The U.S. team, although not involved in the certification process, absorbed all the knowledge related to the process.

Considering the tools used beyond the meetings done physically in the same place, the teams communicated through e-mails, teleconferences and net meeting.

Finally, the requirements phase, considered a critical phase in any project, was performed to satisfaction. This was possible because of the work that all teams did in order to minimize cultural differences, communication problems, trust problems and the work related to the SW-CMM Model level 2 certification process. In the end, the project was delivered before the planned date.

4.3.2. Project 2. The project was developed without problems. It had highlights and problems, and many solutions had been implemented in common agreement between the geographically distributed teams.

Considering just the geographic team distribution, the following issues were found:

Problems:

- Lack of customer work standardization, due to its geographic distribution (teams in many countries);
- Lack of trust in the project beginning related to the U.S. team, due to the competition between the teams;
- The U.S. team did not have a well-defined process;
- The time zone confused in the accomplishment of requirements gathering meetings;
- Videoconference resources had not been used.

Highlights:

- The initial problems had motivated the definition of working standards;
- The Brazilian Program Manager had participated since the beginning of the project, due to the project and the team sizes;
- The requirements specification was standardized;
- The Brazilian Program Manager spent one week in the U.S. in the project beginning;
- Two members of the U.S. customer team had visited Brazil to know the environment and they were surprised;

- The cultural differences had been absorbed delegating tasks in accordance with the profile and the culture of a team member (i.e. the Canadians were very good in something and the Americans in other things.);
- Three weekly meetings were performed with the customer.

Considering the implementation of the SW-CMM Model level 2, it was also verified a great contribution of the certification process and the use of the requirements management process in a geographically distributed environment. The following issues were found:

Problems:
- The U.S. team was not involved in the certification process. Therefore, the Brazilian team had an additional task to explain why each activity was done that way;
- To be involved in a certification process caused a work overhead.

Highlights:
- The requirements management process was well defined and was completely incorporated by other teams;
- The implementation of process based on SW-CMM Model helped in the organization and standardization of the activities between the geographically distant teams;
- The use of process was mandatory and helped in the trust acquisition between the teams;

Considering the used tools, beyond the meetings physically the same place, the teams had communicated through e-mails and teleconferences.

Finally, the requirements phase, considered a critical phase in any project, was done very well, despite of some problems due to the project distribution. Many meetings were performed and some communications problems were identified, but all teams worked very hard in order to minimize the problems, mainly those problems related to cultural differences, communication problems and the work related to the SW-CMM Model level 2 certification process. With all this effort, the first phase of the project was delivered on time and without errors.

5. Impacts of GSD in Requirements Management

After the analysis of these two projects, it can be conclude that to manage requirements in a global software development context can become an arduous task if the process will not be well defined and if the teams will not be previously prepared to work in this scenario. Some studies [1], [2] and [13] point to problems such lacks of communication, cultural differences, collaboration, knowledge management, context sharing, lacks of contact between people and the lack and difficulty to use tools to give support to the activities in distributed environments.

What was perceived in this case study is that all the work involving the SW-CMM Model level 2 certification in the Brazilian unit collaborated in a big scale to minimize some problems found in this scenario. The definition of a software development process based on the CMM model brought excellent results related to the distributed environments problems. Also, the teams were able to standardize all the work and to converge in a common understanding about the best approach to develop both projects. So, it can be concluded that many of the efforts spent in the SW-CMM Model level 2 certification contributed to minimize problems like organization, standardization and, sometimes, communication. The training that was applied concerning soft skills minimized the distance impact and some problems related to these things (trust, cultural differences, etc). All these issues take to believe that, despite the existing difficulties in working this way, a good training is a key to success.

5.1. Lessons Learned

Many lessons were learned during the developing of these two projects, considering the requirements management phase. In the following table there is a list of the main lessons learned:

Table 1. Lessons Learned.

No.	Lesson
#1	Training the team in soft skills (trust, cultural differences, communication, collaboration, context sharing, knowledge management, etc.) is essential.
#2	Work standardization is mandatory.
#3	Frequent meetings with people geographically distant are very important to track the project.
#4	A well-defined process is a key to success.
#5	If it's possible, travels can occur to meet each team involved in the project.
#6	The time zone can act as an advantage and a disadvantage at the same time.
#7	The use of tools like email, conference calls and videoconferences are very important.
#8	To have a certification process like SW-CMM Model level 2 in parallel can increases the overhead, potentially leading to overload.
#9	The SW-CMM Model level 2 certification process helped to define a standard way to work.
#10	It's very important to know about the people that your are working, considering the way to communicate, cultural differences, etc.

6. Conclusions

This paper advances the knowledge in the GSD area when identifying some important characteristics of the requirements management phase in a distributed environment, in parallel with a SW-CMM Model level 2 certification process. As result, many important issues were identified and many lessons were learned. A comparison can be done between the two projects analyzed, in order to understand the way that each team did his work, considering the distribution level and the teams profile.

This study enables a better understanding of the GSD area and the relationship between the project team, customers and users related to the requirements management phase. It is also applies in projects the standard created for comparison between different organizations [11], opening space for new research in this area. Due to the small number of case studies, the results cannot be generalized. In this phase of the study can be adopted the analytical generalization principle, proposed by (Yin 1994).

This preliminary set of results that we are finding give us trustful indication that the search for greater formalism in the development process and the selective utilization of international pattern will provide full conditions to overcome the linguistic and cultural differences, particularly in requirements management, which is the focus of this paper. As contributions of this study, it can be highlighted the lessons learned and the main advantages in having training in soft skills and a well-defined process to work in distributed environments. Moreover, a certification process in a quality model and a continuous software process improvement are very important to succeed.

This study was not considered an analysis of the reasons than can take an organization to adopt strategies of distribution, nor the software development process by itself. Planned follow up studies in this topic will analyze the changes in a general way, considering not only requirements management, but also in all project phases. Some alternatives will be searched and solutions related to the GSD process identified, considering all difficulties and critical success factors like culture, communication, coordination, trust and cooperation.

7. References

[1] Damian, D., The study of requirements engineering in global software development: as challenging as important, *Proceedings of International Workshop on Global Software Development – ICSE 2002*, Florida, USA, 2002.

[2] Evaristo, R., and Scudder, R., Geographically Distributed Project Teams: A Dimensional Analysis, *Proceedings of the Thirty-third Hawaii International Conference on Systems Sciences*, 2000.

[3] Grinter, R. E., Herbsleb, J. D., and Perry, D. E, *The Geography of Coordination: Dealing with Distance in R&D Work.* ACM, 1999.

[4] Herbsleb, J. D., Mockus, A. Finholt, T. A., and Grinter, R. E, *An Empirical Study of Global Software Development: Distance and Speed*, IEEE, 2001.

[5] Herbsleb, J. D., and Moitra, D., *Global Software Development*, IEEE Software, pp. 16-20. March/April/2001.

[6] Mark C. Paulk, Bill Curtis, Mary Beth Chrissis, and Charles V. Weber, "Capability Maturity Model, Version 1.1," IEEE Software, Vol. 10, No. 4, July 1993.

[7] McConnel, S., *Rapid Development***.** Microsoft Press, 1996.

[8] Oberg, R., Probasco, L., and Ericsson, M., "Applying Requirements Management with Use Cases", *Rational Software White Paper*, Cupertino, CA, 2000, pp. 3-5.

[9] Pressman, R. S., *Software Engineering: A Practitioner's Approach.* Fifth Edit, 2001.

[10] Prikladnicki, R., Peres, F., Audy, J., Móra, M. C., and Perdigoto, A., Requirements specification model in a software development process inside a physically distributed environment, *Proceedings of ICEIS 2002*, Ciudad Real, Spain, 2002.

[11] Prikladnicki, R., Audy, J., and Evaristo, R., Distributed Software Development: Toward an understanding of the relationship between project team, users and customers, *to be presented in ICEIS 2003*, Angers, France, 2002.

[12] Yin, R. K, Case study research: design and methods, Sage, 1994.

[13] Zowghi, D., Does Global Software Development Need a Different Requirements Engineering Process?, *Proceedings of International Workshop on Global Software Development – ICSE 2002*, Orlando, Florida, USA, 2002, 53-55.