DISTRIBUTED SOFTWARE DEVELOPMENT: TOWARD AN UNDERSTANDING OF THE RELATIONSHIP BETWEEN PROJECT TEAM, USERS AND CUSTOMERS

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Abstract: The objective of this paper is to propose a typology for distributed software development comprising the relation between the three main stakeholders: project team (developers, analysts, managers, testers, system administrator, etc), customers and users. We propose a set of criteria to define geographically distributed environments. As a result, a model to define the distribution level for an organization in a Distributed Software Development (DSD) environment is presented. The model is applied to two exploratory case studies and its results discussed. These cases studies involve companies with headquarters in the United States and a development unit in Brazil. Advantages of this model as well as some aspects of the increasing distribution of software development particularly in a few Brazilian organizations are discussed.

1. INTRODUCTION

The number of organizations distributing their software development processes worldwide aiming at heightened profit and productivity as well as cost reduction and quality improvements keeps increasing. Many authors (Peters, 2001; Pressman, 2001; PMBok, 2000; Sommerville, 1995; Audy, 2001; McConnel, 1996; Prikladnicki, 2002) point out problems and challenges in the software development process. One of the most significant challenges involves the software development process based on physically distributed teams and environments, also called Distributed Software Development (DSD).

The globalization of the economy, the increasing competitiveness of the enterprise, the strong pressure for cost reduction, allied with the strategic role of Information Technology in organizations, has stimulated the software development process in worldwide scale. This environment created a new class of problems for the researchers in the area of software development, focused on the DSD.

This paper has the purpose to contribute to the literature on such problems by establishing a set of concepts and characteristics of software development projects in a physically distributed environment. Our contribution is in analyzing the definition criteria for a DSD environment and developing a classification of distribution levels. The empirical part of this study involves two software development centers with units in the US and Brazil.

This manuscript has the following structure: section 2 presents the theoretical base used; section 3 describes the criteria for defining physically distributed environment; section 4 discusses the research method used; section 5 presents some real situations where DSD exists; section 6 presents a proposal of classification of distributed levels; section 7 presents the final considerations, directions for future studies and limitations.

2. DISTRIBUTED SOFTWARE DEVELOPMENT

As said by (Pressman, 2001), 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, the software project teams have also been geographically distributed in worldwide, which characterizes the DSD, also known as Global Software Development and Multi site Development, where stakeholders involved in the process are physically distant (Herbsleb, 2001).

Some tools have been developed over the last few years to help in the coordination of the development teams working in distributed environments. Moreover, (Herbsleb, 1999; Grinter, 1999) point out that to work with DSD is one of the biggest business-oriented challenges that the current environment presents under the point of view of the software development process. Many companies are distributing its software development process in countries such as India, Ireland and Brazil.

Organizations search for competitive advantages in terms of costs, quality and flexibility in the area of software development (Prikladnicki, 2002), looking for productivity increases as well as risk dilution (McConnel, 1996). Many times the search for these competitive advantages forces organizations to search for external solutions in other countries. One of the possible alternatives involves outsourcing and offshore outsourcing, epitomizing the traditional problems and the existing challenges in DSD.

2.1 Outsourcing

Outsourcing is defined as a way to contract an external organization to develop a system, instead of developing in-house (McConnel, 1996). Organizations that avail themselves of outsourcing services can concentrate in its core businesses, potentially reducing the software development team

(Pressman, 2001). The combination of these factors results in a significant reduction in time and cost of software development. But (Herbsleb 1999; Cockburn, 2002) point out that outsourcing needs much more management than in-house development. And, when the process is managed correctly, the advantages of this alternative do come true.

One of the outsourcing options that have become popular is offshore outsourcing. Offshore organizations are companies located in another country, offering better costs, quality and schedule than the organizations themselves (McConnel, 1996). The stabilization of the concepts, the development of models and tools to act in this environment has motivated diverse researchers and companies to develop studies and to search for solutions for this new class of problems.

The choice of outsourcing by an organization does not necessarily characterize a physically distributed software development environment, since the outsourcer can perform its activities on site. The distribution of the software development process only occurs when part of the involved in the process is physically distant.

3. DSD CRITERIA ANALISYS

3.1 DSD CRITERIA

In 2001, at OOPSLA[i], promoted by ACM[ii], a panel with some of the main researchers in the software development area proposed the following question: *How is it possible to have an agile development if the development team is physically distributed, each one working in its house*? All researchers converged on the same answer, having affirmed, "We wouldn't even try (DAD 2002).

Moreover, in this panel, there was evidence that diverse experiences involving the distributed software development were being carried through, but none of them involved real cases, with pressures of time, cost and goals, so common in every project. They were just studies of theoretical base.

Many authors have been concerned with the identification of criteria for DSD. The works carried through for (Altmann 1998; Biuk-Aghai 2002; DAD 2002; Evaristo, 2000; Evaristo, 2001). The main criteria identified are presented as follow:

● Physical distance of the actors (DAD 2002);
● Distribution of the project team (DAD 2002);
● Development outsourcing (McConnel, 1996);
● Cultural differences (Evaristo 2001);
● Project Size (DAD 2002; Evaristo, 2001);

3.2   CRITERIA ANALISYS

In DSD, three types of actors are involved in the process:

● The **project team (P)** encompasses everybody involved in the development of a project, potentially including also a set of sub-teams. This team can involve people from the business-oriented area, project management, development, testing, quality assurance and technical support, etc;

● The **customer (C)** is the person or the organization that requested and contracted the development of the project;

● The **user (U)** represents people responsible for supplying all necessary information (requirements) to successfully finish the software project; also responsible for using the final product.

Sometimes, customers can be also users and vice versa. Furthering the analysis of the criteria identified in the theoretical base of this study (section 3.1), it was concluded that:

● **Outsourcing** is not by itself a criterion of DSD. Many organizations have used the concept of outsourcing to represent a strategy business-oriented where a unit (subsidiary) of the organization located in another country or state becomes responsible for the activity involving the software development process. This characterizes in-company outsourcing, something a little different than traditional outsourcing. There are many examples of organizations that adopt this strategy in the area of software development (DELL Computers, Nestlê, HP, Bank of Boston, etc). Therefore, the outsourcing issue will be approached as a characteristic of the participant teams of the development process and not as a DSD criterion.

● **Cultural differences** in a DSD environment emerge as a result of the cultural differences between the different people and involved cultures. These differences can cause many problems potentially compromising the results. Despite its importance, we are not considering it in this study aiming to identify criteria that characterize the distribution level. However, the form that the cultural differences are treated can be considered a critical factor of success in the DSD process.

● **Project size** is an important criterion in the DSD, because it indicates the size of the necessary team, the volume of demanded documentation, etc. This criterion also is not applied for this study for effect of characterization of level of distribution of the DSD. It is one of the factors that can take a organization to opt for distributed development, as well as cost and schedule.

Thus, the next topic will detail the criteria employed to characterize a DSD environment.

3.2.1 Actors' Physical Distance

The physical distance between the actors is a criterion used to define how distant the three actors involved in the process and their respective areas of business are. For this criterion, five scenarios have been defined helping identify the main type of existing physical distance and its characteristics. The scenarios are defined in the following way:

● *Same physical localization Scenario*: this is the situation where all the involved actors and teams are physically co-located (room, building, university). Figure 1 illustrates this situation:
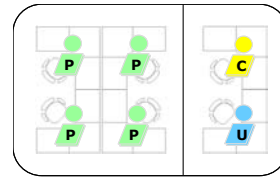

Figure 1: Same physical localization scenario.

● *Cross Town Scenario*: this is a situation where the team is located in the same city. In this scenario the team can have meetings almost daily. Figure 2 illustrates this situation showing a team located in Porto Alegre, Rio Grande do Sul, Brazil.
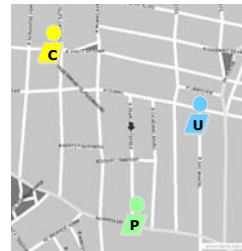

Figure 2: Cross Town scenario.

● *No Time Shift Scenario*: this situation is characterized for having a team located in the same State or Country, having meetings in short intervals of time. Figure 3 shows a team located in the state of Rio Grande Do Sul, Brazil.
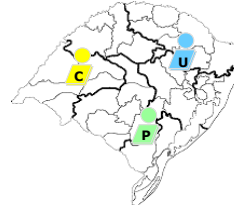

Figure 3: No Time Shift scenario.

● *Continental Scenario*: this situation is characterized for having the team distributed inside the continent. Some difficulties can be seen to having meetings with all team, but some travel can

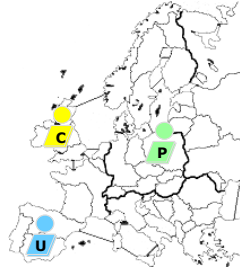still occur. Figure 4 illustrates this scenario, showing a team located in the European continent.

Figure 4: Continental scenario.

● *Global Scenario*: this situation is characterized for having each team member in some place around the world. In this situation, normally all team members can have a meeting in the beginning of a project. Figure 5 illustrates this scenario, showing a team distributed in 3 continents.
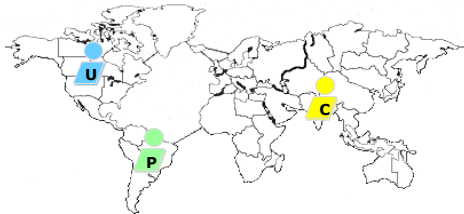

Figure 5: Global Scenario.

3.2.2 Project Team Distribution

Even though the software development process team (customer, user and project team) may be physically distant from each other as described in some of the previous five situations, this does not imply that the project team itself is distributed. A distributed software development environment can have the project team in two main situations:

● *Distributed Project Team*: the project team itself is distributed, therefore working in physically distant locations. This could happen because each team member is physically distant from the other members, or because development sub-teams are distributed. Figure 6 illustrates these possibilities:
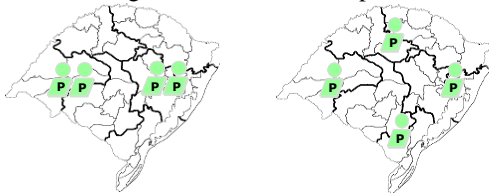

Figure 6: Distributed Project Team.

● *Centralized Project Team*: this situation indicates that the project team is located on the same physical space, or either will always work physically together. Figure 7 illustrates the project team located in the same physical space.
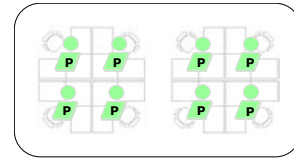

Figure 7: Centralized Project Team.

It is relevant to point out that the distribution of the project team does not consider the localization of the other actors, i.e, customer and user.

In summary, the physical distance between the actors (3.2.1.) and the project team distribution (3.2.2.) are identified as the criteria considered for the characterization of a DSD environment.

4. RESEARCH METHOD

This research is characterized as a study mostly explanatory, with the objective to support a proposal of a typology for distributed software development. The empirical research method was the case study.

In this study, it is possible to justify the usage of qualitative methods since it involves the study of the system development process in its real context, with description and the comprehension of the art state in those situations where practice precedes theory (Yin, 1994). The explanatory research has as main objective to develop, clarify and change ideas and concepts, focusing on new theories, models and researchable hypothesis on former studies.

The case study method adopted is in accordance with (Yin, 1994). Two case studies, one at DELL Computers and another one at Oikodomo Global Technologies have been developed. The unit of analysis was the software development environment. We strived to apply the criteria and distribution level proposed to both studied organizations.

The next section describes two case studies where the objective was to validate the application of the criteria mentioned above in two software development organizations with headquarters in the US and offshore software development units in Brazil (*Dell Computers* and *Global Oikodomo Technologies*).

5. CASE STUDIES: REAL DSD ENVIRONMENS

The characterization of a geographically distributed environment to be used in the software

development process depends on the organization and the project to be developed. The DSD process can be implemented in the company itself (where customer, user and project team work in the same company), or involving other companies, (where customers and users do not belong the same company of the project team).

The case studies developed describe two real DSD environments. The first one, developed in the second semester of 2001, describes an organization where the three main stakeholders (project team, customer and user) are employees (Dell Computers). The second one was developed in the first semester of 2002, describes an organization that has only one project team, and the customers and users are external actors who contract the software development services of this organization (Oikodomo Global Technologies).

5.1   Dell Computers

DELL Computers has an e-business research and development center, being responsible for the e-business corporative software development, that is, systems that will be used in-house.

The projects that are developed in this research and development center have internal customers and users, and are paid projects. All the projects are exclusively developed to supply the internal demand of the organization. Moreover, the distance between the project team and customers and users is very large. So, it is necessary some tools or mechanisms of communication and frequent travel.

Considering that Dell has this center in Porto Alegre, Brazil, and the headquarters are located in the U.S., the three actors that are involved in the development process are in a **continental scenario**, where the client and/or the user are located in the U.S. while the project team is located in Porto Alegre, South of Brazil.

Finally, some project team members are outsourced, having been contracted for a specific period of time. The outsourced employees are physically next to the project team. Figure 8 illustrates the configuration of this development environment.
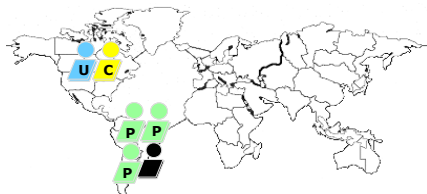

Figure 8: Scenario 1 – Dell Computers.

In this case, the three stakeholders are physically distributed, but the project team is located in the same physical space, having outsourced members

5.2   Oikodomo Global Technologies

Oikodomo Global Technologies has a software development center in Porto Alegre (south of Brazil). This center is responsible for all organizational software development worldwide.

The projects developed in this center have external customers and users (other organizations or people), and are paid projects. The organization develops both customized as well as off-the-shelf software packages. Considering that the organization has this software development center in Brazil and its headquarters is located in the U.S., the three actors involved in the development process are in a **continental scenario**. Customers and users are located in countries like Canada and the U.S. The project team is located both in Porto Alegre (south of Brazil) and the Unites States, having a **distributed project team**, since the business analysts are in the U.S. while the other project team members are in Brazil.

Some project team members are outsourced being contracted for a specific period of time. Figure 9 illustrates how the software project development occurs in this organization.
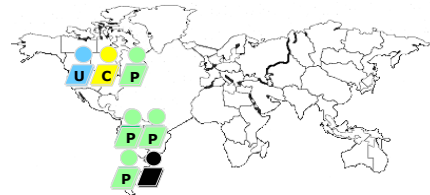

Figure 9: Scenario 2 – Oikodomo.

Besides the distribution between the project team and customers and clients, there is also a distribution in the project team. The organization has business analysts located in the US (they take care of all clients in all countries listed before), and the remaining of the project team is located in Brazil.

6.   DISTRIBUTION LEVELS: A CLASSIFICATION PROPOSAL

Distributed Software Development (DSD) can be defined as a software development process where at least one involved actors (project team, customer or user) is physically distant from the others.

With this definition, it is verified a necessity to define the level (degree) of the organization existing distribution. The following criteria are proposed, in order to establish the DSD distribution level:

● Inter-Group Physical distance;
● Intra-Group Physical distance.

The **inter-group physical distance** defines a distance between the involved actors (project team, customer and user). The **intra-group physical distance** defines a distance inside each stakeholder group (for instance, inside de project team, or the set of users). The physical distance may take any of the five possibilities presented in item 3.2.1.

Using the stakeholders identified (Project Team, Users and Customers), the next step is shown in Figure 10, graphically representing the proposed criteria to define the level of distribution of the DSD (inter-group and intra-group physical distance), and the relationship between these criteria.
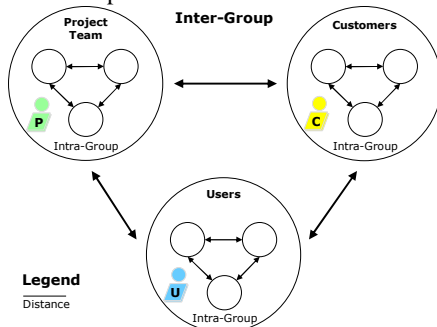

Figure 10: DSD Distribution Level.

In the classification proposal, it can be defined that the biggest level of distribution of each criterion determines the level of distribution of the organization as a whole for this criterion. That is important to help in the process definition and to analyze if the level of distribution can be responsible for some difficulties in the software development.

6.1 Applying the proposed model

Having the two case studies illustrated previously and the proposal regarding the classification of the distribution level, each organization can be classified in the following way:

Dell Computers (in case of *Dell Computers / PUCRS* E-Business Research & Development Center) has the following distribution level:
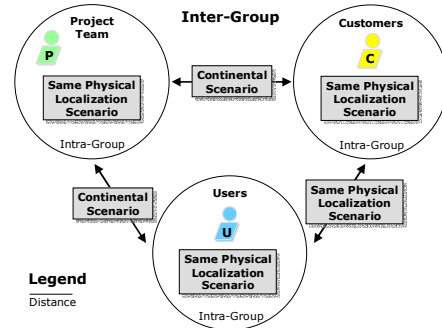

Figure 11: *Dell Computers*.

Considering the distance inside each stakeholder group (intra-group), it was verified that:

● The whole project team is located in Brazil in the same facility (therefore same physical localization scenario).
● Customers and users are located in the U.S. All customers are collocated to each other. The same applies to the user group.

Considering the distance between the stakeholders (inter-groups), it was verified that:

● Customers and users are located in the U.S. very close (same physical localization scenario), since they are located in the same building, and in some projects they can be the same people.
● The project team (Brazil) is on a continental distance (continental scenario) in relation to the users (U.S.) and customers (U.S.).

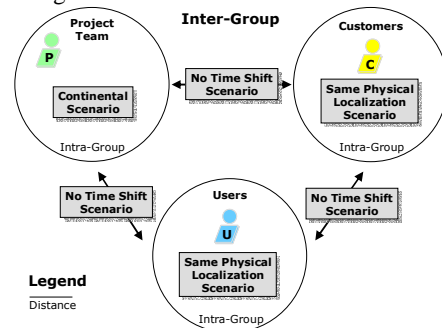*Oikodomo Global Technologies* The Oikodomo Brasil Software Develoment Center has the following distribution level:

Figure 12: *Oikodomo Global Technologies*.

Considering the distance inside each stakeholder group (intra-group), it was verified that:

● The project team has business analysts located in the U.S., whereas other project team members are in Brazil. Thus, there is a continental distance (Continental Scenario) between all of them. In this case, the project team that is located in Brazil is only in contact with the project team located in the U.S.

● Customers and users can be located in the U.S. or in Canada, and they are also closely located inside each group.

Considering the distance between the stakeholders (inter-groups), it was verified that:
● Customers and users can be located in U.S. and Canada. Thus, this characterizes the "No Time Shift Scenario" between them.
● The project team (Brazil and U.S.) presents a regional distance related to users and customers, (No Time Shift Scenario), since only the project team located in the U.S. is responsible for contacting customers and users.

7. CONCLUSIONS

This paper advances the knowledge in the DSD area when identifying criteria that characterize DSD environments and that allow the classification of the distribution levels in an organization. We strived to verify in two cases the applicability of the proposed model. As result, the proposed model allowed the characterization and classification of the distribution levels of each organization studied.

This enables a better understanding of the DSD area and the relationship between the project team, customers and users. It is also creates a standard for comparison between different organizations, 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).

As contributions of this study, it can be highlighted the development of the criteria characterizing the DSD (actors' physical distance and project team distribution), as well as the criteria allowing classification of the distribution level (inter-group physical distance and intra-group physical distance), that form the model proposed in Figure 10. Moreover, these criteria consider three stakeholders involved in the process, and therefore they also establish a new way to define DSD as being a software development process where at least one of the stakeholders (project team, customers and users) is physically distant from the others

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 and consider alternative solutions related to the DSD process, considering all difficulties and critical factors of success like culture, communication, coordination, trust and cooperation, besides analyzing what these criteria defined in this paper represents in this context.

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[i] OOPSLA - http://oopsla.acm.org/.

[ii] ACM - http://www.acm.org.