Towards a Model for Task Allocation in Distributed Software Development

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Abstract. *The management of distributed software development projects presents many challenges. One of them consists of the allocation of tasks between remote teams. When allocating a task, the project manager takes into account factors such as technical expertise and time zone. The project manager usually makes this decision in a subjective way. The verbal decision analysis is an approach based on solving problems through multi-criteria qualitative analysis. This paper describes the progress of studies towards the definition of a model for task allocation in projects of distributed software development based on verbal decision analysis methods ORCLASS and ZAPROS III-i.*

1. Introduction

The development of systems is a business that is still growing a lot on the world scenario. Historical players of the computing area, such as IBM, Oracle, SAP and Microsoft, are increasingly consolidated. With the advent of the Internet and the Web, other companies established and consolidated as giants. In this case, Google and Facebook appear as the best examples. These consolidated companies attend to different segments of activity, from industry to trade, from financial system to power generation, from agriculture to civil construction, from entertainment to education. The types of systems are also as diverse as possible: integrated management systems, operating systems, among others.

Time requirements have become more demanding, in other words, clients cannot expect 2 to 3 years for a system or application any more. This dynamic business environment requires organizations to develop and evolve software at much higher speeds than in the past. New methodologies, as the agile ones, arose and brought a new way of thinking about building software, focusing mainly on the result for the customer, i.e. the customer product delivery.

Large software companies often have offices in several different cities, or even, in different countries, to serve customers around the world. The teams in the various offices can have different profiles or expertise. Some teams perform tasks that require proximity to customer, but other tasks can be done remotely. Some kinds of activities can be carried out away from the big cities, where labor is often more expensive. Thus, the companies take advantage of the cheap work force.

Software development consists of several different activities, such as requirements elicitation, analysis and design, coding, testing, among others. Organizations that work with well-designed projects and adopt consistent methodologies can distribute these activities among different sites, benefiting from the best skills of each local team. In this scenario, a company that has remote offices can distribute its work packages in several ways.

In this context, the project manager must decide which task to allocate to each remote team based on various criteria. This is a decision-making problem with a high degree of subjectivity, which is appropriate for verbal decision analysis. Considering the given scenario, this paper describes a proposal of a model to aid task allocation in projects of distributed software development based on the verbal decision analysis methods ORCLASS and ZAPROS III-i. Preliminary researches and initial results are presented.

The remainder of the paper is organized as follows: Section 2 shortly presents issues involving task allocation in software distributed development. Section 3 provides a brief description of the verbal decision analysis methods ORCLASS and ZAPROS III-i. Section 4 describes the preliminary researches towards the elaboration of the allocation model. Section 5 presents some initial results. Section 6 introduces the proposed model. Finally, in Section 6, we provide the conclusions and suggestions for further work.

2. Task Allocation in Distributed Software Development

The allocation of tasks is a critical activity for any kind of project, especially in a distributed scenario. Most of the time, few factors drive the allocation of tasks, such as hand labor costs. Risks and other relevant factors such as the workforce skills, innovation potential of different regions, or cultural factors are often insufficiently recognized (Lamersdorf, Münch and Rombach, 2008).

Many studies about task allocation in Distributed Software Development (DSD) have been carried out along the years aiming at mapping this topic and its features. Lamersdorf, Münch and Rombach (2008) developed an analysis of the existing approaches to distribution of duties that involved procedures for the distributed development, distributed generation, and distributed systems areas. Lamersdorf, Münch and Rombach (2009) conducted a survey on the state of practice in DSD in which they investigated the criteria that influence task allocation decisions. Lamersdorf and Münch (2010) presented TAMRI (Task Allocation based on Multiple cRIteria), a model based on multiple criteria and influencing factors to support the systematic decision of task allocation in distributed development projects.

Ruano-Mayoral et al. (2013) presented a methodological framework to allocate work packages among participants in global software development projects. Marques et al. (2011) performed a systematic mapping, which enabled to identify models that propose to solve the problems of task allocation in DSD projects. They intended to propose a combinatorial optimization-based model involving classical task scheduling problems. Marques, Rodrigues and Conte (2012) performed a tertiary review applying the systematic review method on systematic reviews that address DSD issues on task allocation.

Galviņa and Šmite (2011) provided an extensive literature review for understanding the industrial practice of software development processes and concluded that the evidence of how these projects are organized is scarce. Babar and Zahedi (2012) presented a literature review considering the studies published in the International Conference in Global Software Engineering (ICGSE) between 2007 and 2011. They found that the vast majority of the evaluated studies were in software development governance and its sub-categories, and much of the work had focused on the human aspects of the GSD rather than technical aspects.

Almeida, Albuquerque and Pinheiro (2011) presented a multi-criteria decision model for planning and fine-tuning such project plans: Multi-criteria Decision Analysis (MCDA). The model was developed using cognitive mapping and MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) (Bana e Costa et al. (2011). In Almeida, Albuquerque and Pinheiro (2011a), they applied (MCDA) on the choice of DSD Scrum project plans that have a better chance of success. Simão Filho, Pinheiro and Albuquerque (2015) conducted a quasi-systematic review of studies of task allocation in DSD projects that incorporate agile practices. The study brought together a number of other works, allowing the establishment of the many factors that influence the allocation of tasks in DSD.

3. Verbal Decision Analysis

Decision-making is an activity that is part of people's and organizations' lives. In most problems, to make a decision, a situation is assessed against a set of characteristics or attributes, i.e., it involves the analysis of several factors, also called criteria. When a decision can generate a considerable impact, such as management decisions, and must take into account some factors, the use of methodologies to support the decision-making process is suggested, because choosing the inappropriate alternative can lead to waste of resources, time, and money, affecting the company.

The decision-making scenario that involves the analysis of alternatives from several viewpoints is called multi-criteria decision analysis and is supported by multi-criteria methodologies (Bana e Costa, 1992). These methodologies favor the generation of knowledge about the decision context, which helps raise the confidence of the decision maker (Evangelou, Karacapilidis, and Khaled, 2005). The Verbal Decision Analysis (VDA) is an approach to solving multi-criteria problems through qualitative analysis (Larichev and Brown, 2000). VDA supports the decision-making process through the verbal representation of problems. VDA methodologies can be used for ordering or sorting the alternatives. Among the classification methods, we can mention ORCLASS, SAC, DIFCLASS, and CYCLE. Some sorting methods are PACOM, ARACE, and those from the ZAPROS family (ZAPROS-LM, STEPZAPROS, ZAPROS III and III-i) (Tamanini, 2014).

3.1. The ORCLASS Method for Classification

ORCLASS methodology aims at classifying the alternatives in a given set: the decision maker needs these alternatives to be categorized into a small number of decision classes or groups, usually two. The first group covers the most preferable alternatives, and the less preferable alternatives belong to the second one (Larichev and Moshkovich, 1997).

The flowchart to apply the ORCLASS method was presented in (Tamanini, 2010). In that scheme, the application of the ORCLASS method can be divided into three stages. In the first stage, the problem's formulation, the set of criteria, criteria values, and the decision groups are defined. Then, the construction of the classification rule is carried out based on the decision maker's preferences. We use the same concepts presented in (Larichev and Moshkovich, 1997), based on which a classification task is presented as a set of boards. Each cell of the board is composed of a combination of values for each criterion defined for the problem, which represents a possible alternative to the problem (Machado, 2012). Finally, the results are generated and analyzed, i.e., the alternatives are classified into two groups, the preferable and the not preferable ones.

3.2. The ZAPROS III-i Method for Rank Ordering

The ZAPROS methodology aims at ranking multi-criteria alternatives in scenarios involving a rather small set of criteria and criteria values, and a great number of alternatives (Larichev, 2001). ZAPROS-III-i method's flowchart to rank order a set of alternatives can be found in (Tamanini, 2010), which is divided into three stages: Problem Formulation, Elicitation of Preferences and Comparison of Alternatives.

In the first stage, the relevant criteria and their respective values to the decision-making process are obtained. In the second stage, the scale of preferences is generated based on the decision maker's preference. In the last stage, the method performs the comparison between the alternatives based on the decision maker's preferences. The method carries out the elicitation of preferences by comparing vectors of alternatives (Tamanini and Pinheiro, 2008).

4. Preliminary Researches

To classify and rank order the most important factors that project managers should take into account when allocating tasks in projects of distributed development of software, we applied a hybrid methodology, which consists of five main steps, as explained in the next subsections.

A - Identification of the Influencing Factors

First, we conducted a literature research to identify the main influencing factors that should be considered when allocating tasks in projects of distributed development of software. Table 1 shows the factors found as result of this research, and that worked as the alternatives to our decision problem (Simão Filho, Pinheiro and Albuquerque, 2015).

Table 1. Influencing Factors on Task Allocation in DSD Projects

ID	Alternatives
Factor1	Technical expertise
Factor2	Expertise in business
Factor3	Project manager maturity
Factor4	Proximity to client
Factor5	Low turnover rate
Factor6	Availability
Factor7	Site maturity
Factor8	Personal trust
Factor9	Time zone
Factor10	Cultural similarities
Factor11	Willingness at site

B - Definition of the Criteria and Criteria values

Next, we interviewed a group of 4 project management experts to define the criteria and the criteria values. This is the definition stage of the criteria. For each criterion, we established a scale of values associated with it (Machado et al., 2010). The criteria values were ordered from the most preferable value to the least preferable one.

As result of this step, we got the list of criteria and criteria values for the problem of selecting the most important factors to be considered in task allocation in DSD projects, which is listed on Table 2 (Simão Filho, Pinheiro and Albuquerque, 2016c).

C - Definition of Alternatives, Decision Groups, and Alternatives' Characterization

We created a questionnaire to gather information and opinions about the factors that influence the allocation of tasks in DSD projects. We applied the questionnaire over the Web to a group of 20 project managers and consisted of two sections. The first section aimed to trace the respondents profile about his/her professional experience and education (Simão Filho, Pinheiro and Albuquerque, 2016c).

The respondents' profiles can be summarized as follows. 30% of respondents have bachelor's degree, 60% have master's degrees and 10% are doctors or higher. All respondents work with software development for over 8 years. 40% work in private companies and 60% in public companies. 65% work in companies whose business is to provide IT services whereas 35% do not. 40% of respondents have between 4 and 8 years of experience in managing software development projects whereas 60% have more than 8 years. 65% have some certification in project management while 35% do not have any certification. 80% of respondents managed more than 8 software development projects and 20% managed less than 8 projects. Considering projects of distributed development of software, 20% of respondents managed more than 8 projects, 55% managed from 1 to 8 projects, and 25% did not manage any project.

The second section of the questionnaire inquired the views of experts on the factors that influence the allocation of tasks in DSD projects (the influencing factors shown in Table 1). For our problem, we described such influencing factors as alternatives. Thus, in every question, the professional analyzed the influencing factors about a set of criteria and criteria values (shown in Table 2) and selected what criterion value that best fitted the factor analyzed.

Table 2. List of criteria and criteria values with description

Criteria	Criteria Values	Description
A: Facility for carrying out the task remotely	A1. It facilitates much	The implementation of the remote task is much easier if the factor is present.
	A2. It facilitates	The implementation of the remote task is easier if the factor is present.
	A3. Indifferent	The presence of the factor is indifferent to the implementation of the remote task.
B: Time for the project	B1. High gain	The presence of the factor can cause much reduction of the period referred to perform the task.
	B2. Moderate gain	The presence of the factor may cause some reduction of the time limit for performing the task.
	B3. No gain	The presence of the factor does not cause changes to the deadline to execute the task.
C: Cost for the project	C1. High gain	The presence of the factor can cause a lot of cost reduction expected to perform the task.
	C2. Moderate gain	The presence of the factor may cause some reduction of the time limit for performing the task.
	C3. No gain	The presence of factor induces no change compared to the estimated cost to perform the task.

Then, we analyzed the responses to determine the criteria values representing the alternatives. For each influencing factor, we filled the final table based on the replies of the majority of professionals. We then selected the value of the criterion that had the greatest number of choices to represent the alternative. Thus, the decision groups were defined as follows. Group I: The influencing factors that will be selected as the most important ones that project managers should take into account when allocating tasks to remote teams (the preferable factors). Group II: The influencing factors that should be less considered by project managers when they need to allocate tasks to remote teams (not preferable factors).

D - The ORCLASS Method Application

We used the ORCLASSWEB tool to aid the application of the ORCLASS method. It is divided into four steps: Criteria and criteria value definition; Alternatives definition; Construction of the classification rule; and Results Generation (Machado, Pinheiro and Tamanini, 2014). In this step, we had the support of an experienced project manager to answer the questions generated by the ORCLASS method to classify the alternatives. The classification rule was completed based on the decision-maker choices. In the end, the tool processed the full classification of the alternatives.

As result of applying the ORCLASS method, we got the following factors to compose the Group I (the preferable factors): Factor1 - Technical expertise, Factor2 - Expertise in business, Factor3 - Project manager maturity, Factor4 - Proximity to client, Factor5 - Low turnover rate, Factor6 - Availability, Factor7 - Site maturity, Factor11 - Willingness at site, and Factor8 - Personal trust. They are the most important ones that project managers should consider when allocating tasks in projects of distributed development of software. In the Group II, which was composed of the least preferable factors, we got the following factors: Factor9 - Time zone and Factor10 - Cultural similarities (Simão Filho, Pinheiro and Albuquerque, 2016c).

E - The ZAPROS-III-i Method Application

After determining the preferred factors using the OSCLASS method, we moved on to the ordering stage. At this stage, we applied the ZAPROS III-i method to put in order the preferable factors, such that it is possible to establish a ranking of preferred factors. In this step, the least preferable factors were discarded, thereby reducing our workspace (Simão Filho, Pinheiro and Albuquerque, 2016a).

To facilitate the decision-making process and perform it consistently, we used the ARANAÚ tool, presented in (Tamanini, 2007). The use of ZAPROS III-i method in the ARANAÚ tool requires four steps. First, we introduced the criteria presented in the problem into the ARANAÚ tool. Next, the decision-maker decides the preferences. The tool presents questionings that can be easily answered by the decision-maker to obtain the scale of preferences.

The process occurs in two stages: elicitation of preferences for quality variation of the same criteria and elicitation of preferences between pairs of criteria. The questions provided require a comparison considering the two reference situations (Tamanini, 2010). Once the scale of preferences is structured, the next step is to define the problem's alternatives. The alternatives to our problem are the preferable factors integrating of Group I.

4.1. Initial Results

After introducing all the data and answering the necessary questions, the decision maker is presented with the result in a table containing the alternatives and their criteria evaluations, formal index of quality and rank, as exposed in Table 3. Note that there are five alternatives (factors) that are in the same ranking position (first position), and their FIQ's values are equals to zero. This occurs because all of them got the best evaluation according to the survey filled out by the professionals (A1, B1, C1), which is the best possible evaluation (Simão Filho, Pinheiro and Albuquerque, 2016b).

Table 3. The final ranking of alternatives

Rank	Alternative	Representation	FIQ
1	Factor1 - Technical expertise	A1B1C1	0
1	Factor2 - Expertise in business	A1B1C1	0
1	Factor5 - Low turnover rate	A1B1C1	0
1	Factor6 - Availability	A1B1C1	0
1	Factor11 - Willingness at site	A1B1C1	0
2	Factor7 - Site maturity	A1B1C2	6
3	Factor4 - Proximity to client	A1B2C2	10
4	Factor3 - Project manager maturity	A2B2C2	11
5	Factor8 - Personal Trust	A2B2C2	11

5. A Proposal of a Model for Task Allocation in DSD Projects Based on VDA

Based on preliminary researches, we propose a model to aid the task allocation in projects of distributed software development. The model is founded on multi-criteria methods of VDA: ORCLASS for classification, and ZAPROS III-I for rank ordering. The proposed model is structured into four activities: (1) problem characterization, (2) rank ordering the preferable influencing factors (for each kind of software development work package), (3) definition of the scoring rules for remote teams, and (4) construction of the comparison method among remote teams.

In order to achieve a more precise and less general result, we decided to replicate the process of determining the influencing factors for the main groups of tasks in a traditional software development process. We intend to take some work packages (also known as “workflows”) from RUP (Rational Unified Process) as starting point, since it is a well known process and widely used throughout the world. Because the following subjects are more likely to be developed remotely, they were chosen to compose the model: requirements, analysis and design, implementation and testing (Kruchten, 2004).

Figure 1 shows a flowchart for the proposed model. The problem characterization activity is divided into three tasks: identification of the influencing factors; definition of the criteria and criteria values; and definition and characterization of the alternatives and definition of the decision groups, for each type of software development task package. In the first task, we will conducted a literature research to identify the main influencing factors that should be considered when allocating tasks in DSD projects. Next, we will interview a group of project management experts to define the criteria and the criteria values in order to assess the influencing factors. Then, we will apply a questionnaire to gather expert’s opinions about the factors that influence task allocation in DSD projects. We intend to apply the questionnaire over the Web to project managers of various companies so that we can define and characterize the alternatives, besides defining the decision groups, for each type of software development task package (requirements, analysis and design, implementation and testing), according to VDA methodologies.

In the second activity, rank ordering the preferable influencing factors, first we will classify the influencing factors into preference groups, according to ORCLASS method. Then, we will rank order the influencing factors of the preferable group, according to ZAPROS III-i method. These tasks will be applied for each type of software development task package.

After that, we will move to the next activity, i.e., the definition of the scoring rules for the influencing factors for each location. This activity is still under research. Finally, the construction of the method to allow the comparison among remote teams will be developed. This activity is also under research. In the end, for each type of work package, we will be able to compare the influencing factors among the various locations and thus choose the location that has the best rate. The team at this place should be allocated to develop the work package.

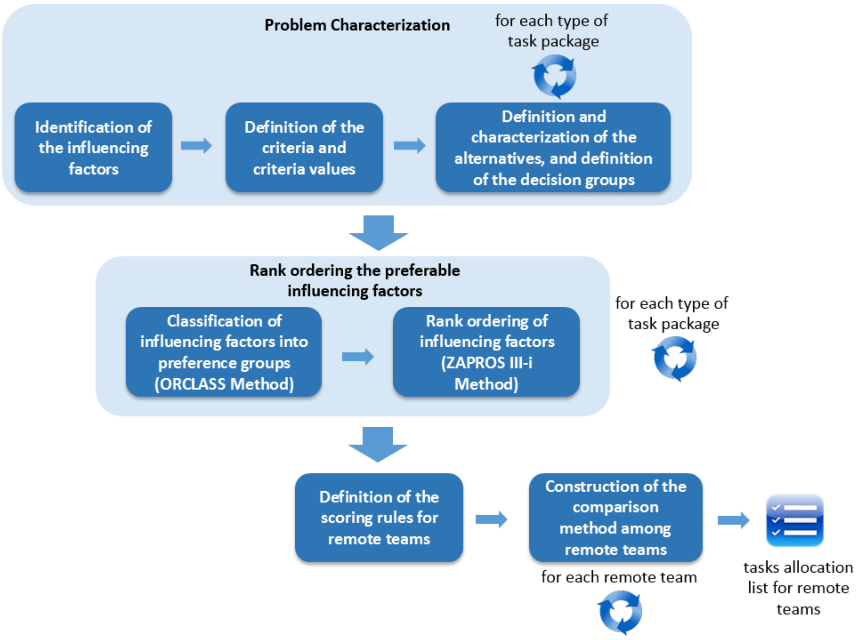

Figure 1. Flowchart for the Proposed Model

6. Conclusion and Future Works

The main contribution of this work was to describe the proposal of a model to aid task allocation in projects of distributed development software based on VDA. The proposal involves applying a hybrid methodology based on ORCLASS and ZAPROS III-i methods of VDA framework to classify and rank order the most important factors that project managers should consider when allocating tasks among distributed teams. Preliminary researches were developed which allowed us to present some initial results.

As future work, we intend to classify the influencing factors into preference groups for each kind of work package based on RUP disciplines. We also need to rank order the influencing factors for each kind of work package based on RUP disciplines. In addition, we plan to define the scoring rules for the factors on each site to allow the comparison among the remote teams. Finally, we intend to apply the proposed model in some real projects, and analyze the results in order to check the efficacy of the model.

Acknowledgment

The first author is thankful for the support given by the Coordination for the Improvement of Higher Level-or Education- Personnel (CAPES) and 7 de Setembro College. The second author is grateful to National Counsel of Technological and Scientific Development (CNPq) via Grants #305844/2011-3. The authors would like to thank The Edson Queiroz Foundation/University of Fortaleza for all the support.

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