COST ESTIMATION IN GLOBAL SOFTWARE DEVELOPMENT

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ABSTRACT

In current world multiple organizations are using the methodology of Global Software Development (GSD) because it is a convenient technique for developing the software projects. Global software advancement serves as a vowed relation among the client and vendor companies. In such relation the client contracts out a part or complete development of the software to the vendor. As a response the vendor provides the services on which the agreement was made in lieu of the payment is made to the vendor as per agreed. GSD method is used because it offers the completion of project in less cost, quick development and the access to experienced resources. Even though GSD is coming out as a successful method but it has multiple difficulties which needs to be overcome such as bad communication, absence of faith and coordination among the team. Due to these challenges there is a significant risk factor in trouble free execution. Our results show that most of the focus in previous research in this area has been limited to highlighting the problems encountered by the client companies. The vendor side up to this time is not very mature because this aspect of GSD is not payed much attention.

Keywords: cost estimation; global software development; challenges; software risk; software quality; communication;

1. INTRODUCTION

Global Software Development (GSD) or Distributed Software Development (DSD) is basically a method of outsourcing which consists of the development teams which are from different backgrounds and are at remote locations. The team then together contributes in developing the software and delivers services. This all is possible via high quality network like internet. The main motive of selecting GSD method is because of its cost efficacy as outsourcing companies typically outsource their agreements to the countries which have less labor costs, which means that the work charge is relatively low as compared to other countries. In spite of the fact that GSD is used commonly, still the project managers contracting the GSD projects encounter multiple problems in planning phase, management of the project and execution of the project. The crucial problem involves the communication between the team members, the coordination between them and to keep their faith with the main stakeholders. Apart from these issues the project managers also encounter issues of cost estimation and time estimation. Plenty of research has been carried out to cater such problems. The part of an architect is spotlighted in [1], on the other hand researchers in [2] emphasized that the client should certainly not be unnoticed. Such issues have given rise to Agile Methodology in GSD. The connection and correspondence between the developing team and the testing team is of great importance [3]. The researchers in [4] have proposed the direction of the research of GSD project planning, managing and accomplishing stages, yet an absolute answer to these issues is until now unavailable. Advancement of technology and use of high speed telecommunication resources has provided the way to utilize the global expertise at minimum payoff. This strategy has shifted the software development groups and maintenance operations to beyond the boundaries by outsourcing or even it can be in-sourcing. There are several challenges while developing software in global environment. Global environment requires more people and more time to complete the project than traditional software development. Different geographic locations increase the effort, cost and other activities to be performed in the project. It enhances the risk of different cultures, different time zones, different languages and coordination and more generates even more issues, problem of understanding requirements and testing tools [5]. Different researchers keep different dimensions regarding GSD on the basis of past studies and surveys such as:

1. Time required to accomplish the DSD/GSD project is 2.5 times longer than collocated due to increase in complexity of environment and task distribution [6].
2. 40% of the projects fail to meet their requirements and to get benefits in GSD environments [7].

The paper is categorized in six parts. The next part of the paper comprises of a concise background of the GSD issues. In the third section of this paper the critical analysis is summed up. The forth section contains the critical review of GSD methods. Towards the end of the paper the future work and conclusions are discussed.

2. BACKGROUND

Organizations outsourcing is where the organization brings in all or few fragments of their product from some other vendor [8]. Outsourcing consists of multiple subcategories like, onshore outsourcing (interchangeably called domestic outsourcing as well). In onshore outsourcing the client and the vendor belong from the similar country but they are not at the same locations. Another subcategory is the nearshore outsourcing. In this type of outsourcing the development team is from neighbor country. In offshore outsourcing the development teams are from different countries [8]. Outsourcing, GSD and DSD are basically diverse names for exclusive software development methods in which the services are provided to the organization from some other source which are the vendors. The parent organizations outsource a part of the project or the complete project because of the less labor cost, fast development and due to the access to expert resources. This method has multiple advantages, yet it has its limitations as well. Few current studies [9, 10] investigate issues in the projects which are developed in a distributed manner. Administration, time, foundation (the infrastructure) and the loop holes created due to the difference of culture which are related with the geographical distance of work makes the management of inter-site reliance of work more strenuous and it becomes even more difficult to collaborate and govern the distributed work.

Many international organizations have already started working on GSD due to its obvious benefits and many are exploring the possibilities to work in. DSD / GSD has number of problems that directly or indirectly affect the process of software development such as inaccurate cost estimates, different time zones because of which the working hours are different, insufficient no of informal meetings, difference of language, faith among the team, no knowledge about the entire picture of competence of the team, ethnic and surrounding differences and absence of social affection among the team as the team members are separated by landmark has remained major focus of research.

Many researchers have highlighted the problems of GSD. A thorough account of the difficulties encountered by GSD and the solutions presented are discussed in this section. Issues like communication, correspondence and control are the prime problems in GSD as discussed in [1]. Thus, the character of the architect is vital as the architect needs to share same framework of the system to all the teams which are the part of the GSD process. The research focuses on adapting the Architectural Description Language (ADL). But it has its limitation which is the understanding of the ADL because of numerous ADLs available. The research in [2] used conventional and agile methodology in GSD. It was discovered that the agile methodology depicted superior results in GSD, yet the study has the limitations that the data used was gathered from just a single team and others were not considered. A disadvantage of agile is that the customer might lose interest because of the excessive number of meetings. Agile method is of the advantage when the projects are large because fast and swift application is done. On the other hand, the project manager might be uncomfortable to have a group on customer side for correspondence when the project is on a small scale because of its budget limitations. Outline provided for correspondence channels suggested by in [2] is shown in Figure 1.

The research in [3] has shown the communication, correspondence and coordination difficulties between the developing team and the testing team and the impression on the project. Multiple problems were identified that arise because of the poor correspondence among the testing and development teams and also the influence of this on the project. Thus, an appropriate model is essential for correspondence between both the teams to resolve their problems. Research was carried out in [8] for control improvement in DSD projects. The results identify the main problems in the project planning and project execution stages. Research in [8] points out the numerous barriers which might have an undesirable impression on outsourcing customers. This study highlights sixteen aspects which include the communication lapse, the uncertainty of the country, interruption in delivery, unseen costs, and mismatch with the customer, deficiency of project management skills, deficiency of technical skills, language constraints, deficiency of project control, bad quality of the process, opportunistic attitude, bad management of the contract made, poor ground work, and bad management of the relationship. But the problems remained unanswered as the study does not provide a solution to tackle these issues.

The research in [11] tells about the China's contributions to get a place in market in development of software and information technology market because of its distinct schemes and procedures. Study in [12] focuses on the significance of communication in the GSD education to the students. It also strains on how important it is to bring the

GSD environment. The research shows that the students are unaware about the GSD. The outline of impression of distance in GSD according to [12] is shown in Figure 2.

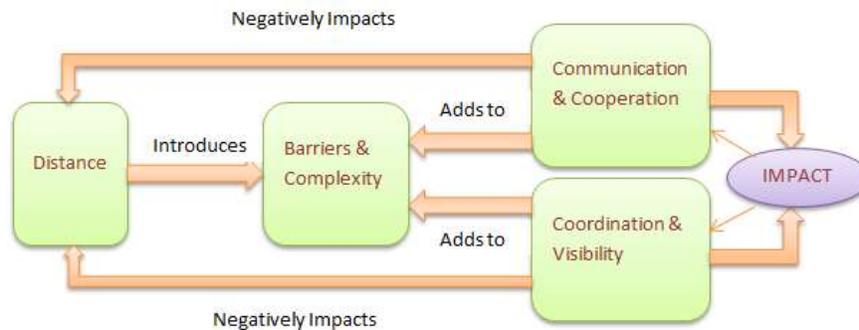**Figure. 1** Communication and its use in projects

Figure. 2 Distance impact in GSD

The researchers in [13] say that formation and maintenance of trust is a critical problem in GSD. The research is grounded on the analysis of the collection of data from eight organizations. For gaining the faith, many organizations bring the culture of consideration, creditability, competences, good project presentation, personal visits and investing in the area of GSD. The research also recommends the tradition of understanding, competences, agreement conformance, superiority, well-timed delivery, progress, management of the potential, one to one dealings and performance as the major components for keeping the faith in correspondence. The research needs more examination

and needs to enhance the work area because the current information is gathered from only one location. The research in [14] shows a structure for the examination and correspondence in GSD. The structure shows better understanding of the examination of correspondence problems in GSD but the structure requires experimental authentication. The research in [15] executes a methodical review to investigate that to what range the distance matters in GSD struggles. The research also provides in depth information regarding nearshore perception and its cons. According to this research the difference of distance among the client and the vendor has a great impact. Researchers in [16] argue on the pros and cons of outsourcing. This argument is in relation to the cost, idleness, superiority, skill set, day and night working, ethnic and linguistic. The research is enlightening in order to comprehend the pros and cons of GSD in a global aspect. It also identified the advantages and hazards linked with GSD in relation to multiple parameters as given in [16] and are shown in Table 1.

Table. 1 Benefits and risks in GSD

	BENEFITS	RISKS
COST	Less cost of labor	Added and unseen costs
UNEMPLOYEMENT	Growing requirements of global talent	Joblessness in most important nations
SKILLS	Endless pool of labor force	Inadequate level of necessary skills
OPERATION	24/7 Operations	Absence of prompt communications
QUALITY	Likelihood of acceptable products	Likelihood of insufficient variances
CULTURE	Broader viewpoints and chances	Difficulties from culture variances
LANGUAGE	Boosting Localization	Difficulties from language differences

The research in [14] shows that the variety in distrusted environment can be improved by using Agile methodology. This research presents three diversity problems which are diversity in gender, managing the diversity and opinion about the diversity as to the Agile methodology. The research emphasizes that role chart is a beneficial practice in the management of the diversity. However, the research doesn't talk about other diversity concerns in GSD for example the ethnic, linguistic, and time diversity. Research in [15] uses the approach of survey to pinpoint the advantages of GSD. It accounts 6 key advantages of GSD, namely:

a) Less cost in the development
b) Time zone usefulness
c) Cross place modularization
d) Availability of large set of expert labor
e) Invention and shared finest practices

3. CRITICAL ANALYSIS OF GSD

The critical analysis of the existing literature is based on research subject, the characteristics and main points highlighted in the research. Table 2 discusses in detail the different research phenomena with respect to the GSD.

Table. 2 Critical analysis of GSD

Serial #	Research Subject	Characteristics	Main Points
1	Superior standard architectural guidance and management are needed in GSD.	The part of architect is spotlighted.	Choice of Abstract Data Language is a crucial decision because of the availability of numerous ADLs.
2	Merging Agile methods and Traditional methods for GSD.	The merger is advantageous for GSD.	Agile approaches have constraints.

3	Measure the efficiency of coordination between the testing team and development team	Pinpoint the problems being faced during the coordination between the testing team and development team. Specifies the negative effect on the project.	Standard framework needs to build for coordination between the testing team and development team.
4	Argument on research guidelines in supremacy structure for DSD projects.	Concerns about the project plan phase and project execution phase and project reflection stages for DSD projects are recognized.	Answers need to be provided for the problems in the research which needs to solved.
5	Highlighting the recognition of the obstacles which are faced in choosing the offshore vendors.	The research highlights 16 aspects which behave as obstacles in choosing the vendors. Following are the aspects: ✓ Communication loophole ✓ Uncertainty of the state ✓ Delivery postponements ✓ Unseen costs ✓ Customer mismatch ✓ Absence of PM practices ✓ Absence of safety for knowledgeable possession rights ✓ Absence of practical competence ✓ Verbal differences ✓ Ethnic differences ✓ Absence of control on project ✓ Inferior services and processes ✓ Cunning conduct ✓ Bad contract management ✓ Bad structure ✓ Bad association organization and strategic stubbornness.	Defines ways to avoid the obstacles need to be considered.
6	Summary strategies and procedures for taking Information Technology and software marketplace.	Survey of efforts put in by China	Mainly a marketing method for information technology and software business
7	Significance of GSD in education for the learners	Study demonstrates that there is absence of GSD teaching in the students; therefore, the issue needs to be considered.	
8	How to create and uphold faith in GSD.	Few parameters for the formation and upkeep of faith in the GSD situation are planned.	Parameters are dig out from the gathered data from only one locality. Additional data is also

			collected to govern additional parameters.
9	Investigation of organization in GSD.	An outline is given for improved understanding & examination of management concerns in GSD.	Outline requires testing and authentication to estimate its efficacy.
10	A relative study of offshore versus nearshore subcontracting.	Research demonstrates that the remoteness has a great impact in GSD.	
11	Pros and cons of sub-contracting.	Pros and cons of sub-contracting are argued in relation to cost, joblessness, worth, periods, and day and night operations, ethos and linguistic.	
12	Identification of the main paybacks of GSD.	6 success aspects in GSD are as follows: ✓ Less cost in the development ✓ Time zone usefulness ✓ Cross place modularization ✓ Availability of large set of expert labor ✓ Invention and shared finest practices ✓ Greater closeness to market and client.	Research does not show the implementation procedure to implement these aspects.
13	Improvement of diversity in GSD in agile.	Research tells that development in agile can highlight the concerns of gender and administration in GSD [17].	Additional diversity concerns in GSD e.g. ethnic, linguistic, etc. needs to be discovered.
14	Requirement for making a computerized tool to support project administrators.	The pros and cons of development site for subcontracting reasons can be highlighted by the said tool. Therefore, aids project administrators in making acute judgments [18].	Tools are useful in huge GSD projects to measure the performance, effectiveness and tendency.

4. COST ESTIMATION IN GSD

GSD is more challenging and requires more attention as compared to collocated development environment. This activity becomes more complicated when distance is included as main factor of development environment [19]. Distance increases the complexity of the development environment and requires more effort and upfront investment to perform the activities in this environment.

Different researchers have worked to define the techniques how to estimate cost in collocated environment but it is still to be defined for GSD environment. There are different tools and techniques defined to estimate cost in collocated environment, but very less work is performed to estimate cost for GSD environment. Only COCOMO II [2, 10] and refinement of few other techniques are found in research [10] covering estimation of cost in GSD by managing very few factors. Other tools and techniques defined for traditional software development environment do not support cost estimation in GSD environment. Software cost estimation is the key activity of software project planning phase. It is very important to have more realistic estimates [6]. There are several methods and techniques defined in last 3 to 4 decades to estimate the project cost and effort. But it is still challenging area with high complexity attracting the researchers' attention [17]. There are different ways to categorize Cost Estimation Techniques present in literature.

There are two main types of estimations performed in software development. One is Quantitative and other one is Qualitative. Quantitative Estimation further lies in two categories. One based on historical data called Empirical estimation modeling and other one based on mathematical expressions and different formulae called Analytical estimation modeling [17].

4.1 Model-based techniques

Model based techniques are based on mathematical modeling. These uses multiple cost factors to determine cost, effort and sometimes schedule. These techniques are dependent to historic data and produces accurate results by incorporating extensive historic data set. These models do not consider uncertain conditions like behavior of stakeholders, personnel efficiency, and team working issues etc. There are different models developed using this technique. Few of them are listed below:

a) Putnam/Software Life Cycle Model

This model is developed in late 1970s by Larry Putnam by using Rayleigh Curve method for specific size project completion and defining the required time and effort. This model uses the equations to calculate effort and schedule of a project [20]. Where S represents size of the project, E is used to include Environment Factors and D is used as the representation of Degree of Reusability factor ranging 8 (no reusability) to 27 (high reusability) in the project [21]. This model is frequently used to construct effort as a function of time and preferred by managers due to its simplicity

b) Function Point Analysis
c) Constructive Cost Model
      i. Modes of Software Development
      ii. Basic COCOMO
      iii. Intermediate COCOMO
      iv. Detailed CocomoPrice-S
d) Estimacs
e) SEER-SEM
f) Checkpoint
g) Cocomo II
h) Agile Cocomo

4.2 Expert-based techniques

There are few techniques that are expert-based to estimate the cost. Some of these techniques are listed below.

a) Delphi Technique
b) Work Breakdown Structure
c) Analogy
d) Work Distribution Technique
e) Top Down
f) Bottom Up

4.3 Learning Based Techniques

a) Case Based Reasoning
b) Neural Networks

4.4 Regression Based Techniques

a) Ordinary Least Square Technique
b) Robust Regression

4.5 Composite Techniques

a) Bayesian Approach
b) Cost Estimation, Benchmarking and Risk Analysis (Cobra)

Multiple features of GSD have been considered for analysis which comprises of architectural organization, rapid development of the software, keeping in view the communication and correspondence problems and have faith in global software projects. The study also has a canvas for the developing need of the projects and encouraging GSD tools to get advantage of outsourcing by carrying out a procedure and by following certain rules and strategies which are for the GSD projects.

In this research we discovered that many researchers have contributed on the major problems of GSD which are faced by the clients/customers and the outsourcing companies. But barely any researcher has worked on the issues encountered by the vendor/supplier companies when they undertake the GSD projects. Thus, we plan to encounter this problem in the future work. The future work will comprise of the subsequent questions.

Research Question 1: What are the difficulties encountered by vendors in the stage of planning of the GSD projects?

Research Question 2: What can be the appropriate practice to encounter the problem being faced by vendor?

The answers to the mentioned queries we aim to take review to pinpoint the problems of this domain and to find the best practices. We will carry out survey and interview to gain understanding of the current scenario.

5. CONCLUSION

Companies have started outsourcing because of the convenience it provides in terms of less labor cost in some areas. The further types of outsourcing for example, offshore, far shore, nearshore and onshore are very common and are excessively used in GSD business. This method provides the benefits of less cost but it has problems for clients and vendors. Problems like correspondence, faith, communication, and coordination are key concerns. The time difference is another key problem because of which the clients and vendors communication is even more challenging which becomes a crucial issue while making outsourcing projects. The ethnic and cultural difference contributes in the challenges faced while making the project in GSD fashion. This research performed a critical investigation of the current outsourcing methods and the main issues encountered by the organizations in this perspective. It pinpoints that there is a need for rigorous research which needs to be conducted to figure out answers to the issues encountered by the vendor/clients of such projects.

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