Challenges of the Existing Tools Used in Global Software Development Projects

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Abstract— **Global Software Development (GSD) has been embraced by organizations due to the availability of highly trained software engineers at a relatively low cost. GSD is not a risk free activity as several GSD failures have been reported. It is anticipated that the appropriate use of available software tools can play an important role in overcoming some of the risks associated with management of GSD projects. However, there are many challenges in adopting the existing tools in globally distributed projects. The objective of this paper is to identify challenges of existing tools used in GSD projects. We have used a Systematic Literature Review (SLR) approach by applying customized search string derived from our research questions. We have identified 105 papers that discuss the challenges of the existing GSD tools. We have identified key challenges for adopting existing tools in GSD projects, such as: "difficulties in adopting and learning existing tools", "inappropriate use of tools", "lack of coverage of GSD processes" and "lack of security and privacy". Based on our SLR results, we suggest that GSD organizations should address these challenges in order to compete in the GSD business.**

Keywords-Global software development; Challenges; Systematic Literature Review; Software Tools.

I. INTRODUCTION

Global software development (GSD) is becoming a promising methodology to build quality software at a low development cost and short time-to-market. GSD is the process where a company either has its software developed by geographically distributed teams or contracts all or parts of its software development activities in return for remuneration [1] [2]. A number of software organizations in the developed world have outsourced their software development projects to emerging countries (e.g., China and India) where they have access to large pools of highly trained software engineers at relatively low cost.

The adoption of GSD has introduced potential benefits as well as challenges for software organizations. GSD has dramatically changed the business economics in the overall software industry by, for example, utilizing time-zone differences to organize round-the-clock project development life cycle. Furthermore, globalization of software projects allows companies to employ software engineers with required skills to work on a project from different geographical locations. On the other hand, the geographically distances and cultural differences between globally distributed teams have also introduced new challenges, such as: difficulty in maintaining collaboration, coordination and communication [3] [4] [5] [6].

Lately, researchers [7] [8] have indicated that readily available software tools can help in overcoming challenges associated with development and management of software projects by GSD teams. Document management systems, wiki and blog features of software tools have been used for knowledge management among GSD teams. Similarly, social computing tools, such as: Skype, Twitter, etc., are being used in multi-site GSD projects to provide additional communication channels. This not only enables real-time communication but also allows knowledge sharing and instant feedback from different teams involved in the project [9].

Despite the increased use of software tools in GSD projects, little research has been carried out to comprehend the challenges associated with the adaptation of existing tools in the GSD environment. We also need to investigate how to help organizations in selecting suitable tools to ensure the successful outcome of projects and to maintain long lasting relationships between the clients and the vendors.

In this paper, we aim to identify challenges, via systematic literature review, of using existing software tools in GSD projects. Identifying these challenges will assist GSD organizations in better development and management of GSD projects. Our long-term research goal is to develop a global project management readiness framework to assist software development organizations in measuring and improving their project management readiness prior to starting global activities. To achieve this, we intend to address the following research question in this paper:

RQ: What are the challenges of existing tools used in GSD projects?

The rest of this paper is organized as follows: Section II provides the GSD background. Section III describes the research methodology. In Section IV, we present the initial results with analysis and we conclude in Section V.

II. BACKGROUND

GSD is a software engineering paradigm aiming at developing high-quality software in low-wage countries at reduced cost [1]. The various types of GSD projects can be grouped into two categories, namely, outsourcing on the basis of geographical location and outsourcing on the basis of relationship [10]. On the basis of geographic distance between vendors and clients, outsourcing is further

categorized into three types: onshore outsourcing, near-shore outsourcing and offshore outsourcing [11]. Onshore outsourcing is also called domestic outsourcing, which consists of both domestic vendors and domestic clients [12]. This means that both (vendor and client) organizations are located in the same country. Near-shore outsourcing or simply near shoring is defined as the transfer of software development work to a nearby foreign country to reap lower labor cost advantages [13]. Offshore software development outsourcing refers to outsourcing in a geographically distant country. The offshore activities have been going on since the last decade and are growing rapidly [14]. The major vendor countries for offshore outsourcing are India, Ireland, China and Russia whereas the client countries are USA, UK, Australia and Japan [15].

There are many reasons for initiating GSD project [13] [14] [15] [16]. Client organizations benefit from GSD because vendors in developing countries (offshore vendors) typically cost one-third less than onshore vendors and even less when compared with in-house operations [17]. Among many other reasons for GSD, generally client organizations outsource their software development work to offshore locations to gain quality advantages, improve their skills, access to leading-edge technologies and focus on their core competencies [13]. Conversely, there are many risks in the GSD, such as: temporal incompatibility, cultural differences and hidden costs [18] [19]. IT Week magazine reported that eight out of every ten firms that outsourced their software development project to an offshore vendor faced major problems due to insufficient preparation and poor management by both client and vendor organizations [20].

There are many reasons for these problems. One of the major issues is the lack of awareness about software tools support for GSD projects and what features they provide to support globally distributed software development projects. Understanding issues related to adoption of suitable software tools to support different phases of GSD can help in achieving greater success in GSD projects. In this paper, we conduct a systematic literature review to identify challenges of the existing tools used in GSD projects.

III. RESEARCH METHODOLOGY

In this study, we followed the systematic literature review (SLR) process to find the data required to address our research question [21]. SLR is a defined process that aims at providing an exhaustive summary of literature by identifying and analyzing published studies relevant to the investigated research question [22]. SLR may use scoring of the levels of evidence or statistical techniques (meta-analysis) to combine results of the identified studies. Therefore, the results obtained from SLR may provide a better insight than might be in ordinary literature review or surveys.

To conduct the SLR, we developed the systematic review protocol. The protocol describes the plan for the review. The SLR includes the following main steps:
- Define the search strategy
- Search for relevant studies
- Select relevant studies

- Perform study quality assessment
- Extract data from the finally selected studies
- Analyze the extracted data

In order to achieve the objective of this paper, we set the following research question:

RQ1: What are the challenges of existing tools used in GSD projects?

For the above research question, we identified the following major terms:
- POPULATION: GSD projects.
- INTERVENTION: GSD challenges of existing tools.
- OUTCOME OF RELEVANCE: the challenges of existing tools used in GSD projects.

Finally, after a number of trials, we identified the following search string that is used in this study:

{Challenges OR limitations} AND
{Technology OR tools} AND
{GSD OR Global Software Development OR Global Software Engineering OR Global Software Testing OR Software Outsourcing OR Software Offshoring OR Geographically Distributed Software Development}

We used the following digital libraries to run our search string: ACM Digital Library, IEEE Explore, Science Direct, Springer Link and John Wiley.

The following inclusion criteria were used:
- The paper should be related to GSD.
- The paper should clearly mention at least one challenge or limitation either for a certain tool used in GSD or for technology used in GSD in general.
- The following exclusion criteria were used:
- Non-English papers were excluded.
- White papers and technical reports were excluded.
- Papers related to technology used by distributed teams other than software engineering were rejected.

To address our research question, we extracted data from the finally selected papers. The following data were extracted from each paper: publication type, authors, publisher, publication name, publication date, organization size, project size and challenges of tools used in GSD projects.

IV. INITIAL RESULTS AND DISCUSSION

Table I shows the SLR process results. A total of 1318 papers were retrieved after entering the customized search string in the digital databases. After reading the title and the abstract, 318 papers were selected. Finally, 105 papers were selected after reading the whole paper.

The finally selected papers were categorized according to the nine study strategies as shown in Table II. Most of the articles have used case study research method.

Table III provides details of the publication venues for the papers identified in our SLR study. Nineteen papers are from Finland, eighteen papers are from USA, nine papers are from Germany, six papers are from Brazil, five papers are from the Netherlands and four papers are from UK.

TABLE I. SEARCH EXECUTION

Library Name	Total Results	Initial Selection	Final Selection
IEEE Explore	980	250	82
ScienceDirect	88	13	6
ACM	180	34	7
John Wiley	70	21	10
Total	1318	318	105

TABLE II. STUDY STRATEGIES USED

Study Type	Count
Case Studies	29
Literature Review	16
Implementation	21
Interviews	10
Empirical	8
Systematic Literature Reviews	6
Systematic Mapping Review	4
Social Network Analysis	1
Others	10
Total	105

From the accepted papers, 8 challenges of the tools used in GSD projects were extracted as shown in Table IV.

TABLE III. STUDY COUNTRIES

Country	Count	Country	Count
Argentina	2	Malaysia	1
Australia	3	Mexico	3
Brazil	6	Netherlands	5
Canada	3	New Zealand	2
China	1	Norway	2
Denmark	4	Pakistan	1
Finland	19	Spain	3
Germany	9	Sweden	2
Iran	1	Switzerland	1
India	4	UK	4
Ireland	5	USA	18
Italy	4	Venezuela	1
Latvia	1		

In our study, the most common challenge of the tools used in GSD projects is "inappropriate use of synchronous and asynchronous communication tools" (43%) as shown in Table IV. This can be due to multiple reasons, such as:

- The synchronous tools are useless when the time difference among the remote teams is more than 8 hours, i.e., no working time overlap between different teams and thus they cannot utilize these technologies unless one team shifts the working hours.

- The synchronous interaction causes interruptions for the employees in their daily work as often unnecessary communication is performed. Some team members may nudge each other without knowing the status of the receiver (i.e., if receiver is busy in an important meeting or meeting a crucial deadline).

- During the use of synchronous and asynchronous communication tools, the GSD professionals often face problems due to cultural and language differences.

- Asynchronous communication tools like email or forums are not appropriate for solving conflicts and technical interactions due to their late responses.

TABLE IV. LIST OF CHALLENGES

Challenges	Freq. (n=105)	%
Inappropriate use of synchronous and asynchronous communication tools	45	43
Difficulties in adopting and learning existing tools for GSD projects	31	30
Lack of coverage of GSD development processes.	26	25
Lack of data integration due to different collaboration tools used in GSD projects.	21	20
Lack of support for collaboration and group decision making.	12	11
Lack of security and privacy in communication and collaboration tools.	10	10
Lack of awareness of existing tools used in GSD projects.	6	6
Lack of ability to track the progress of tasks assigned to team members in GSD projects.	5	5

The second frequently mentioned challenge is "adopting and learning new tools for GSD projects" (30%). This is because there is an increasing pool of software tools that can be used in GSD projects and selecting and adopting the most appropriate tool from this pool is a challenging task. This may be due to the absence of a well-defined procedure to select the best tool. In addition to that, some people are reluctant to use some tools due to cultural issues. Moreover, some people are resistant to change and therefore they do not like to replace their current tools with new ones.

All these problems show that most of the GSD organizations do not design the adequate communication strategies. It is very important to early develop a good communication strategy in order to reduce misunderstandings between stakeholders from different country cultures [2].

The other highly mentioned challenge is the "lack of coverage of GSD processes" (25%). None of the existing tools cover all processes in the GSD life cycle. Most of the tools are dedicated for a specific function like communication, testing, requirements engineering etc. As a result, the GSD companies need to have many different tools

to perform different GSD functions. In addition, there are important GSD areas, which are rarely covered by the existing tools, such as: risk management, requirements engineering, issue tracking and social awareness.

20% of the articles mentioned "lack of data integration due to different collaboration tools used in GSD projects". This incompatibility is due to the absence of standards for the different tools vendors. This challenge complicates the data transfer among these different tools.

10% of the articles have mentioned "lack of security and privacy in communication and collaboration tools" as a current technology challenge in GSD projects. These security issues are related to source code and project information that is exchanged over the web. There are also privacy concerns for the team members when using these tools for informal communication, such as: instant messaging or social media.

V. LIMITATIONS

We limited our SLR study to four research publication databases. However, there are other related research databases which we did not consider in our study, which may have relevant publications. Furthermore, with the increasing number of research papers published on this topic, some recent and relevant publications could have been missed at the time of consolidating the results of the SLR. Nevertheless, we believe that our presented results are comprehensive and cover the most relevant published literature.

VI. CONCLUSION AND FUTURE WORK

There is a growing interest in GSD for software development companies. In addition to the challenges that are related to the GSD business nature and cultural differences, there are other challenges associated with the tools used in GSD. In this paper, we identified challenges of the software tools used in GSD projects from the existing literature. We identified 105 papers that discuss the challenges of the existing GSD tools and technologies. These challenges range from unsuitable or missing features in these tools to the non-existence of tools in some GSD areas. There are other challenges related to the cultural and time zones difference issues. In addition, the existing tools are neither comprehensive nor compatible with each other to allow tools integration.

The next step is to conduct an empirical study to support our findings. This includes designing a questionnaire in the light of our findings and gathering information from the software industry professionals about the challenges related to the tools used in GSD projects.

The overarching objective of this research work is to develop a global project management readiness framework to assist software development organizations in measuring and improving their project management readiness prior to starting any global software development activities.

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