CHALLENGES OF ADOPTING SOCIAL COMPUTING IN GLOBAL SOFTWARE DEVELOPMENT

BY

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My parents

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LIST OF ABBREVIATIONS

CSCW	:	Computer Supported Cooperative Work
DD	:	Distributed Development
GSD	:	Global Software Development
GSE	:	Global Software Engineering
GSW	:	Global Software Work
IM	:	Instant Messaging
ISSD	:	Inner Source Software Development
IT	:	Information Technology
OOSD	:	Open Source Software Development
SE	:	Software Engineering
SLR	:	Systematic Literature Review
SN	:	Social Network
SoSo	:	Social Software

ABSTRACT

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Social computing is seen as a promising area to solve various issues of Global Software Development (GSD). However, there is a wide assumption in the literature and industry that GSD firms are reluctant in adopting social computing tools due to some challenges. In this thesis, we propose to investigate challenges that stop GSD companies from adopting social computing tools. Systematic Literature Review (SLR) and questionnaire are the research methodology used to guide us in finding the answer of our research question. 'Miscommunication', 'Organization structure and policy', 'Knowledge management' and, 'Multiple communication channels' ranked the top four challenges founded in the literature respectively. Whereas, 'Miscommunication', 'Knowledge management', 'Security' and, 'Organization structure and policy' placed the top four challenges in the global software industry survey. Based on the outcome produced by these two methods a significant Spearman's rho of (0.582) is obtained by correlating SLR and questionnaire results. This work aids GSD researchers and practitioners in identifying the challenges of adopting social computing in GSD settings. We hope that our research will facilitate any future research on how to solve these challenges.

ملخص الرسالة

الاسم: مصطفى محمد الصالح

عنوان الرسالة: تحديات تبني الحوسبة الاجتماعية في تطوير البرمجيات عالمياً

الدرجة العلمية: ماجستير العلوم

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ينظر إلى الحوسبة الاجتماعية باعتبارها منطقة واعدة في حل مختلف القضايا المتعلقة بتطوير البرمجيات عالمياً (GSD). ومع ذلك، هناك افتراض واسع في الأبحاث وصناعة البرمجيات أن شركات تطوير البرمجيات العالمية يترددون في اعتماد أدوات الحوسبة الاجتماعية بسبب بعض التحديات. في هذه الأطروحة، نقوم بتحديد التحديات التي توقف شركات تطوير البرمجيات العالمية من تبني أدوات الحوسبة الاجتماعية. طريقة البحث المستخدمة هي المراجعة الممنهجة للأدب (SLR) والاستبيان، والذين يقومان بتوجيهنا في العثور على إجابة سؤال البحث لدينا. 'سوء الفهم '، ' الهيكل التنظيمي وسياسة المنظمة'، ' إدارة المعرفة' وكذلك ' قنوات الاتصال المتعددة ' حازوا على أعلى أربعة تحديات في مراجعة الأدب على التوالي. في حين أن ' سوء الفهم '، ' إدارة المعرفة '، ' الأمن ' وكذلك 'الهيكل التنظيمي و سياسة المنظمة' حازوا على أعلى أربعة تحديات في استبيان صناعة البرمجيات عالمياً. استنادا إلى النتائج من خلال هاتين الطريقتين تم الحصول على ارتباط كبير (٠,٥٨٢) Spearman's rho عن طريق الربط بين نتائج المراجعة الممنهجة للأدب (SLR) والاستبيان. هذا العمل يساعد الباحثين والممارسين في تطوير البرمجيات عالمياً في تحديد تحديات اعتماد الحوسبة الاجتماعية في بيئة تطوير البرمجيات عالمياً. نأمل أن هذه الرسالة ستسهل أي عمل في المستقبل على كيفية حل هذه التحديات.

CHAPTER 1

INTRODUCTION

1.1 Overview

A considerable number of software organizations aspire to provide services across national borders but this new model exhibits many challenges. Global Software Development (GSD) is a complex, specialized type of distributed software development environment due to the high dispersion of global software work which is undertaken at geographically separated locations across national boundaries in a coordinated fashion involving real time and asynchronous interaction [6] . These challenges can be vital and have significant impact on the success of GSD projects as more than half of GSD organizations are reported to fail.

Outsourcing plays a significant role in today's business due to the availability of cheap labor or the utilization of new services. In this model, two parties are involved vendors and clients. The client delegates some services to a third-party vendor on a fee basis. Outsourcing services can be locally transferred or provided by companies located abroad. Outsourcing on a global scale is gaining acceptance and many outsource companies extend their services to multiple continents. An estimation by the US that the GSD market for the last decade has increased by 25% [7].

By contrast, the various online communications environment that involves a social factor collectively known as 'Social Computing' are flourishing. Though the benefits of adopting social computing into GSD environments are appealing, there are as many challenges. These challenges differ in their impacts over the GSD activities. A previous work suggests that half of the companies that have tried GSD have failed to realize the anticipated outcomes which has resulted in poor global relationships, misunderstanding of the projects' requirements, high costs and poor services which leads to project failure [8]. A Significant issue cited in the literature was that plenty of GSD firms were not ready to adopt social computing in their GSD activities [9]. The performance of team members in GSD projects will be noticed and increased if their tasks are designed with the right communication media in mind. Despite the importance of this challenge, little research has been carried out to address the GSD processes of organization using social computing concepts. Understanding issues relating to social computing for GSD initiatives will help to ensure the successful outcome of projects and to maintain long lasting relationships between clients and vendors in different geographical locations.

Within this focus, the objective of this research is to investigate the challenges of adopting social computing in GSD. An ultimate outcome of this research is to aid GSD organizations to better realize the challenges of adopting social computing which may lead them to adapt to these challenges and mitigate their side effects.

The emergence of internet and new communication technologies has its impacts on the way business is conducted. Social computing refers to collection of tools and programs which act as a platform for individuals and groups to communicate and

collaborate efficiently regardless of their location. The benefit of this platform can be transformed and implemented to aid the collaboration and coordination of global distributed projects. Although GSD, due to its nature, is heavily based on excellent communication and collaborations; organizations tend to underestimate the urge of effective collaboration and communication practices [10]. Hence, social computing provides a seamless and convenient collaboration platform. It's of no surprise to find that most of the members working in GSD projects are non-native English speakers. It has been acknowledged that social computing tools, unlike direct communication channels like telephones, can assist them in rechecking their points and formulate their standings [5]. An empirical study of the benefits of social computing into different business sectors is discussed by Gill et al. [11]. The study assures the interest of many organizational firms toward the adoption of social computing.

Though social computing has several potential advantages and implications in many business and technology domains, there is a significant lack in the literature of the associated challenges of adopting these technologies. Moreover, the need of exploring all factors that hinder GSD organization from adopting social computing must be studied and analyzed thoroughly from the literature. Following that, opinions from the industry are necessary to validate the outcomes from our literature. In addition, the industry data will provide us with an overview on the practical issues associated with implementing social computing tools.

The adoption of social computing occurs at different stages of project development. Some companies use social computing tools at the initial stage to communicate with their customers on which ideas should be developed first. Others find

it helpful to perform it during the implementation or testing phases as a coordination mechanism.

1.2 Research Question

This research is aimed to answer the following research question:

RQ: What are the challenges of social computing adoption in GSD organizations?

Identify the challenges of social computing adoption in GSD organizations

A systematic approach will be employed with the intention of achieving the thesis objectives to identify the challenges of social computing adoption at GSD organizations. This approach will be implemented by using the concept of 'Systematic Literature Review' (SLR). The identified challenges by the results of this SLR will be empirically studied, and a questionnaire will be designed based on the results to explore the software industry experience and to discover the software experts' knowledge at GSD organizations regarding the thesis problem. The contribution of the thesis will provide the researchers and software industry with a solid foundation and a body of knowledge which may help them to develop different social computing activities based on better understanding of how and where they fit into global software development business and which consequently, would help in addressing the high number of failures currently reported for global software development projects.

The following approaches are used as a guide for answering our research question:

1. Identify the challenges of social computing adoption at GSD organizations using systematic literature review methodology.

2. Identify the challenges of social computing adoption at GSD organizations via online distributed questionnaire targeting industry experts.
3. Analyze the results of steps 1 and 2 to identify if there is any significant correlation between the literature and software industry.

1.3 Research Methodology

We will conduct a Systematic Literature Review (SLR), which is a well-defined and rigorous method to identify, evaluate and interpret all the relevant studies regarding a particular research question, topic area or phenomenon of interest. A systematic review is a defined and methodical way to summarise the empirical evidence concerning a treatment or technology, to identify missing areas in current research or to provide background in order to justify new research. Systematic reviews require considerably more effort than conventional literature reviews, but provide a much stronger basis for making claims about research questions [1] . Hence, an SLR was an appropriate research method for our research that is aimed at highlighting the challenges that GSD organizations may face when they decide to adopt the social computing tools to communicate and to focus more on the challenges with high importance that may lead the project to hinder or fail. We will follow the SLR guidelines proposed by Kitchenham and Charters [1] for performing SLR which contains three main processes identified:

1. ***Planning the review:*** by specifying the research questions and developing the review protocol which contains the search strategy by identifying search strings derived from the research question, scopes and methods. In addition to that, the quality assessment of selected

studies as well as the inclusion and exclusion criteria and data extraction forms will be used. Then, we will validate the protocol.

2. ***Conducting the review:*** by identifying relevant researches and selecting the primary studies from them and then to assess the study quality and extract the required data. Finally, we will synthesis the extracted data by checking the most frequent challenge that faces the GSD organizations in using social media. This categorization will help us in defining the challenges with higher priorities which may hinder the project or may lead the project to fail.
3. ***Reporting the review:*** We will write up the final report and do the report validation.

After the results (i.e. challenges of social computing adoption in GSD organizations) have been identified by SLR, we will validate the findings via online questionnaire given to industry experts. The online questionnaire will capture the practitioners' opinions on which challenges they faced in utilizing social computing tools in their GSD projects. A comparison and correlation analysis will be conducted to further highlight the significance of each challenge theoretically and practically. Based on both the SLR and industry experiment we will build a comprehensive challenge basis for social computing adoption in GSD organizations.

The research methodology and approach is summarized into the following phases:

Phase 1: Systematic Literature Review (SLR)

At the first phase we will start the systematic literature review. We have identified the primary resources and research databases to be the following: ACM Digital Library, ScienceDirect, IEEEXplore, SpringerLink, CiteSeer Digital Library and, Emerald.

Phase 2: Empirical Study with Software Industry Experts

At this phase, we will conduct an online questionnaire with software industry experts to validate the SLR results.

Phase 3: Interpretation and analysis:

The results compiled from SLR and empirical questionnaire will be interpreted and analyzed in alignment with the research objectives in order to answer the research question. The SLR data will be analyzed based on a frequency of citation of challenges, strategy types and country of authors. The frequency will show in tabulated form the number of occurrences and percentage of each data. The purpose is to measure the significance of challenges across different continents and among different study types. The outcome will be helpful in understanding which strategy type(s) usually identify more challenges and which strategy type(s) reveal new uncommon challenges. Likewise, analyzing the challenges across various continents may enlighten us on the significance of each challenge in each region. Challenges reported in many continents are considered as common challenges, whereas other challenges that are only identified in a particular region require a careful local attention to the causes and effects of these challenges.

Analysis and interpretation of empirical data will be similar to the SLR approach. Frequency analysis is obtained from experts responses. The frequency analysis will identify challenges most cited by industry experts. In addition, the significance of each challenge in relation to some key items like Age, Gender and Continent will be reported.

In both approaches, statistical techniques are going to be employed namely spearman's rank order correlation.

Phase 4: Conclusion

The conclusions of the whole effort of this research will be presented.

Phase 5: Thesis Writing

Complete the thesis write-up.

1.4 Thesis Outline

The thesis is organized as follows:

Chapter 2 presents the state of the art literature review of the field pointing out the gaps in the literature which is addressed by this thesis. The literature will compose a body of knowledge necessary to justify our purpose of the research. The literature is basically revolved around two axes: Global Software Developments (GSD) and Social Computing (SC). Chapter 3 addresses the research methodology of our research. Basically, our research is conducting a systematic literature review and online questionnaire. All steps, plans and designs will be outlined including the followed protocol. Results are illustrated in tabulated and charted format in Chapter 4. It will be accompanied by extensive interpretation and analysis in alignment with the research objectives. Chapter 5 is drawing a conclusion on our research.

CHAPTER 2

LITERATURE REVIEW

2.1 Global Software Development (GSD)

A global project is a recent category that can be defined as a combination of virtual and international projects, which includes people from different organizations working in various countries across the globe. There are five different dimensions to evaluate the level of complexity of global projects that are identified by Jean Binder [2] as shown in Figure 1.

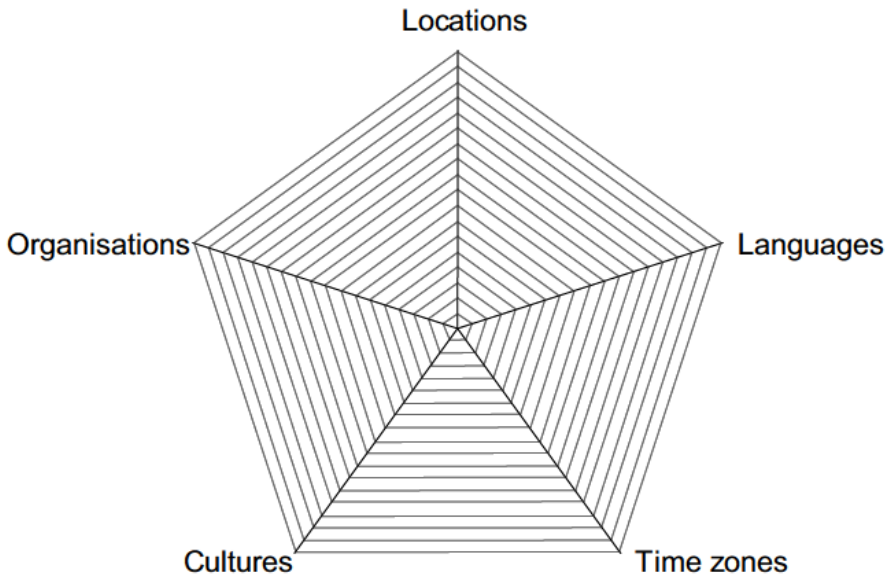


Figure 1 Global Projects Dimensions [2]

By lower complexity level the author refers to a single department, location, time zone, language or culture [2]. Global Software Work (GSW) defined as “software work undertaken at geographically separated locations across national boundaries in a coordinated fashion involving real time or asynchronous interaction. GSW can thus include work done across global borders through outsourcing, alliances, or subsidiary arrangements” [12]. Outsource in dictionary form means: “To procure (as some goods or services needed by a business or organization) under contract with an outside supplier” [13]. In Information Technology (IT) context the outsourcing defined as: “a decision taken by an organization to contract-out or sell the organization’s IT assets, people and/or activities to a third party supplier, who in exchange provides and manages assets and services for monetary return over an agreed time period” [14]. Software development is one of the main services provided by IT organizations and it can be perceived as a knowledge-intensive activity represented in social interactions among the development team members and the separation of spatial and temporal between them exacerbates the tasks of development processes complexity and may lead to delays in accomplishing the tasks in comparing to collocated team members [15].

Global Software Development (GSD), or software development outsourcing, is a recent software engineering paradigm aiming at developing high-quality software in low-wage countries at reduced cost [16] and since it’s an engineering paradigm it is so called also Global Software Engineering (GSE). This paradigm can be viewed as developing software by team members from different geographical locations whether or not these teams or members belonging to the same organization; for example, Open Source Software Development (OOSD) or Inner Source Software Development (ISSD) [17].

Software development outsourcing can be described as an agreement between company (client) where it contracts out all or parts of its software development activities to one or more other companies (vendors) who provide agreed service in return for remuneration [14, 18, 19]. Mainly there are different forms of software outsourcing and they can be grouped into two main categories: firstly, based on the basis of geographic location and, secondly on the basis of the relationship [20]. On the basis of geographic location we can identify the following categories: Onshore outsourcing this occurs when the client and the vendor are located in the same country [21], Nearshore outsourcing which imply to nearby countries where the differences in geographical distance, cultural differences, time zone difference, political/economic differences, and cost of travelling are relatively low in comparing to offshore outsourcing [22, 23], and finally Offshore outsourcing also called farshore outsourcing which refers to outsourcing in geographically distant country [24]. The major vendor countries for offshore outsourcing are India, Ireland, China and Russia whereas the client countries are the US, UK, Australia and Japan. Some of these studies in the literature were focusing on India and China since they are well-known countries for outsourcing in software development discipline, and the studies draw the opportunities, practices and the challenges in these locations [25-27]. While, on the basis of relationship Gallivan and Oh in [4] as the Figure 2 shows have recognized four main types: Simple Dyadic Outsourcing *(One Client, One Vendor)*, Multi-Vendors Outsourcing *(One Client, Many Vendors)*, Co-Sourcing *(Many Clients, One Vendor)*, and Complex Outsourcing *(Many Clients Many Vendors).*

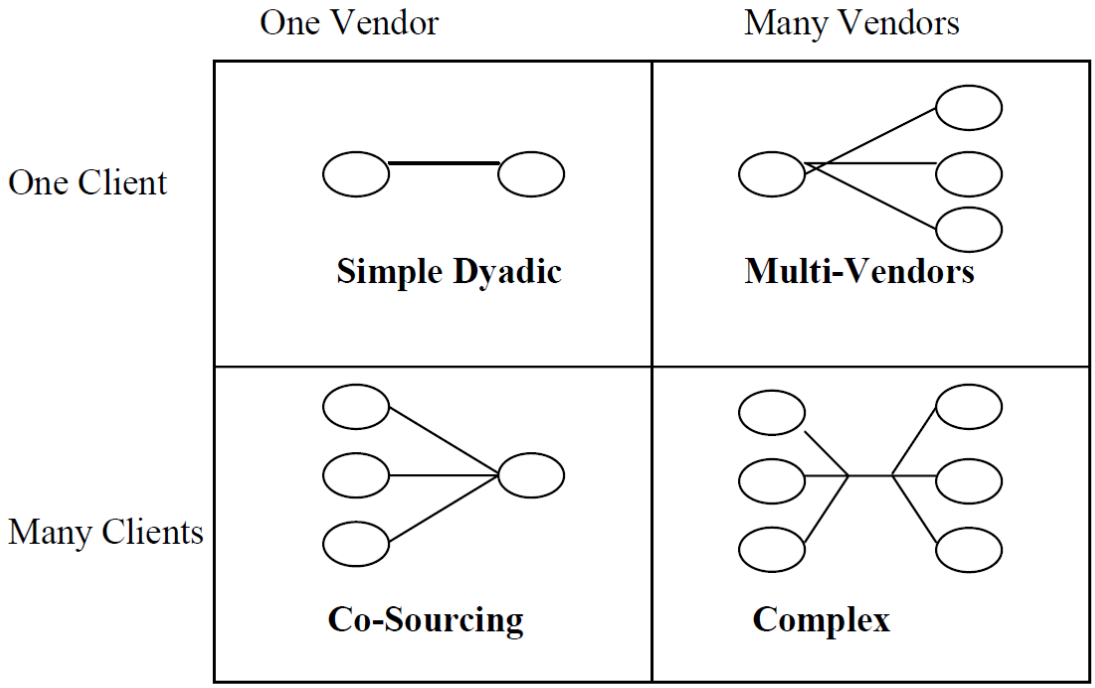


Figure 2 Different Types Of Outsourcing [4]

It can be clearly perceived from the mentioned forms of outsourcing that the more distant country to an organization which implicitly involving higher time and cultural differences and the more number of stakeholders from clients and vendors raise the complexity of outsourcing significantly and in addition to that there are many factors that influence a client selection for their offshore vendors. Cost-saving and skilled human resources are the most important factors that the vendors need to have in order to give a positive impact on their clients [28].

GSD projects usually involve team members from different geographical location to work together in developing a software project. This shift of project development from local site into multi-sites brings some challenges such as: differences in cultures and time zones [29] in addition to an increasing reliance on formal communication channels [30] . This lack of informal channels can cause a trust issue. Not only is building trust difficult but also maintaining that trust along the project is even more challenging [31]. An interesting paper that illustrates the challenges and obstacles that hurdle a real case of GSD project is found in [32]. A special treatment of the time separation issue has been handled in depth by Espinosa and Carmel[33].

The nature of GSD impose the spatial and temporal dispersion among the virtual team members and developers which is challenging; but the rewards of GSD which are ranging from accessing the world-class IT professionals resource pool at very competitive cost to “round-the-clock” running development processes are still attracting the software development organizations [15]. The benefits of GSD have been studied and examined by many researchers such like: reducing costs of development, reducing time to market, cross-site modularization of development work, approaching to enormous

skilful developers pool, innovation and sharing best practices, improved resource allocation, increased team autonomy, formal record of communication, improved documentation, clearly defined processes, and proximity to market and customers [7, 34]. Although some of these benefits are only proven; the effect of software industry globalization has led the software companies to enter the competitive software market through this avenue.

Many issues and challenges are well known and have been acknowledged in GSD despite the dispersion of geographic locations and time differences and there are numerous issues that still open and need to be further studied such as: strategic issues, commitment issues, socio-cultural issues, inadequate awareness, communication, trust and transparency, coordination, control, knowledge management, and project management [5, 7, 15, 35-39].

In GSD Project Management (PM), Niazi et al. [40] recently have pointed out the main challenges in GSD projects and categorized them into 19 challenges. The lack of cultural understanding in teams was at the top of the list and in the second level comes lack of communication. The balance of challenges were ordered from the top to the bottom as the following: time zone problem, lack of coordination, lack of knowledge management and transfer among teams, geographical distance, lack of trust, lack of control, requirements engineering activities, lack of team awareness, change management activities, lack of uniform process among different development sites, conflict management, integration activities, allocation of tasks, risk management, lack of proper IT infrastructure, protection of intellectual property, and lastly cost and effort estimation.

It is notable that Knowledge Management, Requirements Engineering , and Group Awareness in GSD have been studied thoroughly in the literature [41-47] and this is reflected in the importance of these practices in the process of software development especially when these practices are in global settings.

Despite the importance of the above practices and their own challenges, communication, collaboration, and coordination of the work remotely are in the core practices of GSD imposed by its nature and so the researchers have been studying this area since the emergent of distributed work concept. The advent of Computer Supported Cooperative Work (CSCW) has helped them in identifying the advantages and disadvantages in such processes [46]. In addition to that, some studies showed the effect of the distance over the speed on the global work and revealed that this distance may lead to unfavourable delays of work [48-52]. They have suggested that increasing communication is speeding the global collaboration [49].

A framework of Distributed Development (DD) has been drawn by Ågerfalk et al. [5] and the included processes in DD have been divided into three main categories: Communication, Coordination, and Control; they have mapped these categories to the three main dimensions in GSD: Temporal Distance, Geographical Distance, and Socio-Cultural Distance. This mapping is focusing on the challenges and potential threats in DD environment as well as some potential advantages as shown in Table 1.

Table 1 Framework of Issues in DD [5]

Process	***Dimension***		
	Temporal Distance	**Geographical Distance**	**Socio-Cultural Distance**
Communication	☺ Time zone effectiveness ☹ Delayed communication ☹ Delayed feedback	☺ Proximity to market/customer ☹ Lack of informal communication ☹ Dependency on ICT ☹ Increased effort to initiate contact ☹ Providing technical infrastructure ☹ Cost of travel	☺ Innovation and shared best practices 😐 Asynchronous communication preferred by non-native speakers ☹ Language differences and misunderstandings ☹ Managing frames of reference
Coordination	😐 Time zone efficiency ☹ Reduced hours of collaboration ☹ Synchronised team meetings difficult ☹ Availability of technical infrastructure ☹ Coordination complexity ☺ *Modularisation of work* ☹ *Lack of mechanisms for creating shared understanding* ☹ *Management of project artefacts*	☺ Access to large labour pool 😐 Standardisation in work practices ☺ Allocation of roles and team structure ☹ Reduced trust ☹ Lack of awareness/team spirit ☺ Modularisation of work ☹ Lack of mechanisms for creating shared understanding ☹ *Coordination complexity*	☺ Mix of skills and experiences 😐 Language and cultural training ☹ Lack of domain knowledge ☹ Doubtful of others' capabilities ☹ *Lack of mechanisms for creating shared understanding* 😐 *Standardisation in work practices* ☹ *Coordination complexity* ☹ *Lack of awareness/team spirit*
Control	☹ Management of project artefacts ☺ *Time zone effectiveness*	☹ Lack of concurrent engineering principles ☺ *Allocation of roles and team structure*	☹ Perceived threat from low-cost alternatives ☹ Adapting to local formalized norm structures ☹ Different perceptions of authority/hierarchy

Researchers of GSD field realized that those challenges may hinder the software development industry from taking advantage of the unique characteristics of GSD and for this purpose they were almost in the last decade trying to come over these challenges by proposing many solutions especially those dealt directly with the separation of geographic locations and time differences as well as socio-cultural issues since these three dimensions are considered as the main issues in GSD. Some of these proposed solutions were travelling as especially in case of bodily presence is definitely required for overcoming the distance challenge. “Follow-the-sun” concept [53] for time difference challenge as well as keeping flexible and adjustable working hours to get a coordinated time overlap. In socio-cultural dimension some of proposed solutions were to use asynchronous communication channels to overcome the language barrier and allowing the team members to be in continuous communication through different media and building the trust and sharing the knowledge among the teams [54, 55].

Generally speaking, in co-located software development projects the members of teams know each other very well and have been working together on many tasks before, which naturally builds the experience and the shared view of how to coordinate and how to proceed over the lifecycle of the project [39]. But in GSD projects this is not the case and in many cases the tasks are usually shared between collaborators who might be dealing with his colleague for the first time and this evidences that the tasks take a far longer time to be accomplished in comparing to co-located projects [15].

As a discipline, GSD has developed through practice-influencing research and proven practices but there is still an indispensable need for evolving methods and practices formerly in order for GSD to become a mature discipline by itself [38]. This is

due to the lack of empirical studies exploring the work forms exist in GSW/GSD organizations [12]. Sahay et al. [12] commented that: unlike manufacturing and professional services domains that are mature, there are far fewer studies focusing on GSD domain.

Communication plays a vital role in GSD project coordination, management, knowledge collection and transfer among different project shareholders such as customer, managers, business analysts, solution architects, developers and testers [33, 56]. There are many challenges related to communication in the GSD environment due to geographical distances, time, culture and language differences [57]. GSD, especially, offshore outsourcing is not a risk free activity as significant outsourcing failures have been reported [58, 59]. Islam et al. [59] argue that lack of understanding between the client and vendor organization, ambiguous requirements and ineffective development processes may yield substantial risks . The results of a survey shows that eight out of every ten firms that have outsourced their software development project to an offshore vendor have faced major problems due to insufficient preparation and poor management by both the vendor organizations [56]. Nam et al, [56] found from their investigation of 93 client companies that 36 did not intend to continue their relationships with vendors. King [60] reports that JP Morgan decided to perform in house many software activities that it previously outsourced, and did not renew its $5 billion contract with IBM. At the root of many failures is the increased complexity that outsourcing brings to development projects. This complexity results in high coordination costs [61], information security problems [62], lack of direct communication [63], perceived loss of expertise in the outsourced activity [3], cultural misunderstandings [6] and infrastructure problems [64].

Other risks are threat of opportunism, unexpected cost, trust and security concerns, geopolitical risk, and language barriers.

2.2 Social Computing

Social computing is shifting the computation from networking to socialization. Social computing can be seen as “a large number of new applications and services that facilitate collective action and social interaction online with rich exchange of multimedia information and evolution of aggregate knowledge have come to dominate the web” [65]. Many of the current social computing tools such as: (LinkedIn, Flicker, Wikis …etc.) transform the websites into interactive social-based computation. LinkedIn is “a social network for business professionals”. Flicker is “a poplar easy to use photo sharing service”. Wikipedia is “an online open source encyclopedia built by aggregating so called Wikis” [65]. There are many overlapping terminologies with social computing such as: ‘Web 2.0’, ‘Social Media’, ‘Social Network’ (SN), ‘Social Software’ (SoSo) and, ‘Collaboration Tools’. Although there is no clear distinction between these terminologies; it’s obvious that they reflect the same phenomenon [66]. Social computing and Web 2.0 is used interchangeably in academics and industry. Tim O'Reilly argued that there is a big disagreement on Web 2.0 definition. Instead, he presented a table distancing between Web 1.0 and Web 2.0 technologies [67].

Table 2 Web 1.0 and Web 2.0 Services [67]

Web 1.0	Web 2.0
DoubleClick	Google AdSense
Ofoto	Flickr
Akamai	BitTorrent
mp3.com	Napster
Britannica Online	Wikipedia
personal websites	blogging
Evite	Upcoming.org and EVDB
Domain name speculation	Search engine optimization
page views	Cost per click
Screen scraping	Web services
publishing	participation
content management systems	Wikis
directories (taxonomy)	Tagging (“folksonomy”)
stickiness	syndication

Social Computing is a recent field of research in the computing era. It emerges as a form of collaboration among workers in the field of software development. Social computing enables customers to be involved during the course of the project; it aids organizations in achieving customer satisfaction and process transparency.

Social computing is gaining wide acceptance gradually. As illustrated in [68], the adoption rate of various social computing services has increased during the period of

2008-2011. Adoption rate of social network has doubled during that period. Video sharing, Blogs and Microblogging exhibited a similar growth.

The benefits of adopting social computing in enterprises can be categorized into three categories: Internal purposes among staffs, Customer-related purposes, and Suppliers [69]. These benefits include: speed of access, reduction of miscommunication, collaboration enhancement, and socio-culture enhancement. The growth of Web 2.0 tools is impressive, yet its success is associated with human factor. In [70] they concluded based on a distributed survey, that security and governance issues are the main barriers of adoption of social computing.

Different tools of social computing have been incorporated in the development of software projects. 'Wikis', 'Twitter', 'Bookmarks' and various 'mash-up' technologies has been reported in the literature as a collaboration tools [29, 71-73] Gramel et al. think that mashup technology plays a significant role in enhancing the collaboration in Software Engineering (SE) projects [71]. According to [72] , wiki is a brilliant discussion boards that empowers the voice of each team individual. Tagging has also been reported to be of significant assistance to team-based software development [29]. A dedicated study to the adoption of tagging in SE projects is done by [73].

Social computing has transformed the way individuals and groups interact with each other. It encourages the use of different types of collaboration tools by empowering individual and groups to collaborate and share knowledge in order to produce a common output. However, there are a number of issues that need to be considered when intending to adopt social computing technology such as: security, scalability, quality, trust, integration and interoperability from social computing technology perspectives. Social

computing adoption also needs to consider its impact from people and organization perspectives such as: motivations and de-motivations of individuals and groups to volunteer or collaborate by using social computing technologies. It may impact participants welfare and security and in general the reputation of the organization itself. Social computing provides both opportunities and challenges, and therefore, it is important to proceed with great caution because investment in the social computing tools could be a waste of a real source of value.

2.3 Adoption of Social Computing

Adopting social computing tools within an organization is challenging due to the scepticism of this adoption. The scepticism is mainly referred to as: security, control, governance and the lack of measurements that could evaluate the added value for these tools. This is what has been pointed out in a study of two large organizations [74]; a telecommunication company and a bank. The researchers have identified many advantages and challenges when the organizations decide to adopt the social computing to enhance the collaborative work and communications channels among the dispersed employees. Despite the efforts that were taken to convince one of these managements of the importance and benefits of such adoption; high percentage of employees agreed that social computing tools were beneficial and make them complete their works faster which lead to improve their productivity and without any doubt securing and protecting the organizations' shared information were at the top of the challenges in the process of adoption. This is not surprising since many of organizations consider this information

very valuable for them and there is as need to be well protected as any other asset of the organization. Misuse and uncertainty of measuring the tools benefits to the social media is still a challenge as well as involving management and seeking their support in taking action of adoption. The study also gives good indication about the correlation between the user acceptance for using these tools and their ages and it reveals that the younger users tend to accept and use such tools more openly than the older users.

McAfee ensures that such adoption must be widely supported by the organization's management before taking the decision to adopt social computing tools [75]. He pointed out some challenges in such adoption. The challenges were that the users wouldn't use these tools and even if the users did use them as intended, there still a potential that leads to unintended outcomes. Finally, the study ensures once again the role of the organization's management that can play to success or not and to which extent can the organization exploits the advantages of these tools highly depends on the organization's capabilities.

In a recent study [76], the researchers looked at the factors that might influence 'Enterprise Social Software Platforms' (ESSPs) and they assured that the body of knowledge in this discipline is limited. Actually, they have proposed a conceptual model in a previous study [3] and they have validated in the mentioned study. Mainly; three factors where identified: Technological Factors, Social Factors and, Organizational Climate, ass drawn in Figure 3.

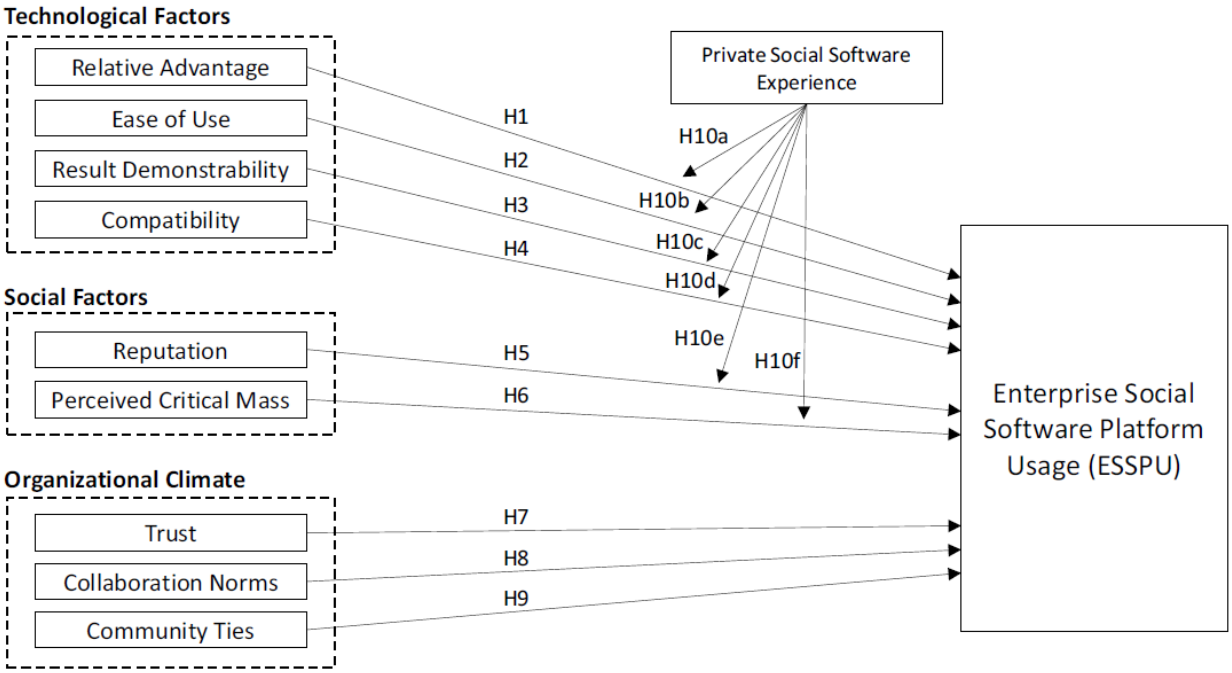


Figure 3 Conceptual Model of ESSPs [3]

Several studies have been conducted to explore the feasibility of adopting social computing in GSD settings or organizations. These studies suffer from some setbacks: narrow perspective such as: (a) looking at the area from one angle like knowledge management [42] or requirements engineering [45, 77, 78] (b) embedding social computing tools to the 'Integrated Development Environments' (IDEs) [79] (c) deploying and implementing for a specific social computing tool or concept [80-84] and finally (d) looking at a specific social computing tool. A study have explored how 'Twitter' is being used in the Software Engineering community [85]. All of the mentioned studies show incoherency and lack of investigating challenges of adopting social computing tools in GSD.

Away from software industry and in the educational environment, Fatma et al. [86] pointed out the importance of teaching students the new methods of communication and collaboration in global settings due to the growing changes in software industry and its transformation to the global development. From three globally distributed schools located in: Turkey, US and, Panama; they have analysed the collaboration patterns in terms of asynchronous and synchronous communications adopting social computing tools in three GSD projects given to the students. The results show that the students tend to communicate more using synchronous rather than asynchronous communication tools.

On the other hand, there are few studies that overlapping in one way or another with our work but there is still no research pointing directly to the challenges of social computing adoption in GSD organizations.

In this year (2013) and in very recent published study, Niazi et al. [87] have investigated the motivators of adopting social computing in GSD. They have categorized these motivations into six main categories as the following: real-time communication & coordination, information sharing, familiarity with GSD team, expert feedback, knowledge acquisition and, innovation. Once more, in a systematic mapping review [88] Rosalba Giuffrida and Yvonne Dittrich have explored the empirical studies on the use of social computing tools in GSD, they assured the shortage in our research area since only 12 studies out of 100 gathered were explicitly reported the use of these tools in GSD! This again shows the importance of this research and how could it help both the academia and practitioners in identifying the social computing adoption challenges in GSD settings. Moreover one recent research, a systematic mapping study, Portillo-Rodríguez et al. [89] gather round all available communication and coordination tools in GSE to give the practitioners a better idea about these tools and how they could help them in their activities for better utilization. Nevertheless, some authors have explored how the social media is being used by the early adopters; they have concluded that adoption of social computing tools in GSD would improve the software quality and at the same time they reveal the necessity of extra exploration of reviewing the impacts of adoption the social media in GSD [90].

There are other few studies about the use of SoSo in GSD and we are going to explore them. In an empirical study about the use and non-use of Web 2.0 in distributed development teams Ban Al-Ani et al. [61] investigated the feasibility of adoption Web 2.0 services in these distributed teams in terms of trust development among the team members; the results show that the adoption was less than expected and it was below

25% of the participants! Mainly they refer the non-use to different reasons such as: non-alignment to the intended work, lack of support, and finally lack of trust of the information exchanged through such technologies. In another study, Aditya Johri challenged the view that Email is irreplaceable by other tools in distributed firms and he showed that these social computing tools can replace Email and give more advantages over it such as: improving communication, make the organization transparent and, support the openness of the working environment [91]. In this context also and in supporting the adoption of social media, Tuomas Niinim¨aki in [92] showed some evidence of that Instant Messaging (IM) could replace face-to-face meetings!

Finally, and in upcoming article planned to be published in 2014 [93], Pirkkalainen and Pawlowski, extended the utilization of SoSo to address knowledge management issues in GSD. The authors presented a set of challenge categories that exist in knowledge management activities.

Our work is on alignment with the previous study in identifying the various challenges adopting social computing. Nevertheless and to the best of our knowledge, no SLR has been done in this area before. Therefore, we are not going to restrict our research to one dimension such as knowledge management. Instead, a holistic perspective of most of social computing challenges manifest in GSD environments are identified and validated through Systematic Literature Review (SLR) and empirical study in industry.

It seems social computing adoption comes with both its de-motivators and motivators. In summary, it provides a network based environment that “shifts computing to the edges of the network, and empowers individual users with relatively low technological sophistication in using the Web to manifest their creativity, engage in

social interaction, contribute their expertise, share content, collectively build new tools, disseminate information and propaganda, and assimilate collective bargaining power" [94]. Despite the growing interest in the use of social computing, the adoption of social computing does not come without its challenges. For example we need to consider the discomfort that it may cause to developers in GSD when information about their activities is easily aggregated and then compared with other developers. This draws our attention to a number of interesting results which we are going to explore in this research project. It is evident that the study of social computing and its use for communication, collaboration, coordination and crowd sourcing of information in GSD are emerging research trends both in academia and industry, however, it underlines the need for further research.

The main contribution of this study is to add to the body of knowledge of both disciplines: GSD and Social Computing and to give the organizations and in particular GSD organizations a comprehensive perception of the challenges that inevitably comes along with the welfares from these technologies prior to adopting them. This will aid them to get better understanding about the surrounding issues of these technologies and acting properly to avoid or mitigate these challenges.

CHAPTER 3

RESEARCH METHODOLOGY

Our research methodology consists of two main parts: Systematic Literature Review (SLR) and a Questionnaire. Prior to starting searching the literature and after reviewing many dictionaries and referring to many studies, we have defined the challenge in this study as*: "Any factor or reason that makes the actual using and implementation of social computing or media is difficult or requires more efforts or skills from the GSD organizations' team members and is considered as a notable issue or concern for them".* This definition will help us in searching and focus on the scope of this work by mapping the extracted challenges from the literature to this definition which aids in validation process.

3.1 Systematic Literature Review (SLR)

We have followed the SLR guidelines proposed by Kitchenham and Charters for performing SLR for data collection since it is well-defined and rigorous method to identify, evaluate and interpret all the relevant studies regarding a particular research question, topic area or phenomenon of interest. A systematic review is a defined and methodical way to summarise the empirical evidence concerning a treatment or technology, to identify missing areas in current research or to provide background in

order to justify new research. Systematic reviews require considerably more effort than conventional literature reviews, but provide a much stronger basis for making claims about research questions [1] . Hence, an SLR was an appropriate research method for our research that is aimed at highlighting the challenges that GSD organizations may face when they decide to adopt the social computing tools to communicate and to focus more on the challenges with high importance that may lead the project to hinder or fail.

A systematic literature review protocol was written to provide the details of all steps that we have followed in our study; the major steps are described as the following:

- Determine the search strategy and perform the search for relevant studies.
- Study selection process.
- Apply quality assessment for the selected study.
- Conducting data extraction and mapping then analysing of the extracted data.

The details of these summarized points depicted in the next figure and will be described in the next sub-sections.

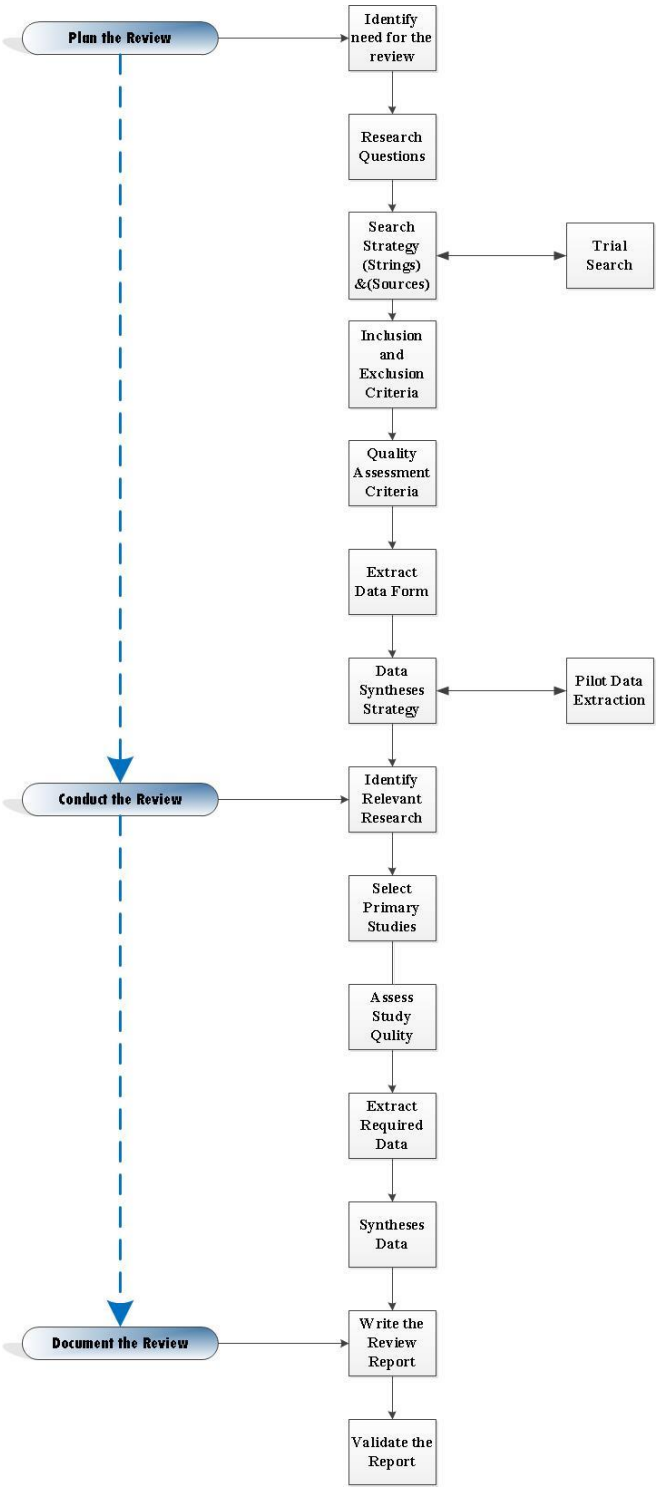


Figure 4 Steps Of Performing SLR [1]

3.1.1 Search Strategy

The strategy used to construct search terms is as follows:

a) At the beginning we have derived the major search terms from the research question by identifying the population, intervention and outcome.
b) Then we have identified alternative spellings and synonyms for the derived major terms to ensure that we don't miss any related study.
c) We have verified and checked the keywords in relevant papers.
d) We have used the Boolean operators: "AND" to concatenate the major terms, "OR" to concatenate synonyms and alternative spellings, where the database allows.
e) Finally, we have integrated the search string into a summarized form, if required.

Result for a

The following details of the population, intervention, outcomes, and experimental designs of interest to the review will form the basis for the construction of suitable search terms later in the protocol.

Population: Global software development organizations.

Intervention: Social computing adoption.

Outcomes of relevance: Challenges.

Experimental design: SLRs, empirical studies, case studies, theoretical studies, expert observation and experience reports.

Here is an example to use the above details to write the research question as follow:

RQ:	
[Global software development organizations]	*Population*
[Social computing adoption]	*Intervention*
[Challenges]	*Outcome of relevance*

RQ: Global Software Development, Organization, Social Computing, Adoption, Challenge.

<u>Result for b</u>

RQ:

Global Software Development : *("GSD"OR "Global Software Engineering" OR "GSE" OR "Distributed Software Development" OR "DSD" OR "Multisite Software Development" OR "Offshore Software Outsourcing" OR "OSDO" OR "Information Systems Outsourcing" OR "Information Technology Outsourcing" OR "IT Outsourcing" OR "Computer Based Information System Outsourcing" OR CBIS Outsourcing")*

Organization*: ("Vendor" OR "Developer" OR "Provider" OR "Community" OR "Company" OR "Establishment" OR "Incorporated" OR "Inc." OR "Firm" OR "Corporation" OR "Corp." OR "Agency" OR "Dealer" OR "Cooperative" OR "Crew" OR "Team")*

Social Computing*: ("Social Networks" OR "Social Media" OR "Social Interactions" OR "Social Communities" OR "Virtual Communities" OR "Online Communities" OR "Social Networks Services" OR "Internet Communities" OR "Web2")*

Adoption: *("Adopting" OR "Acceptance" OR "Implementation" OR "Approval" OR "Agreement" OR "Assumption" OR "Taking on" OR "Choice" OR "Confirmation" OR "Selection" OR "Support" OR "Approbation" OR "Espousal" OR "Embracement" OR "Embracing" OR "Sit")*

Challenge*: ("Issue" OR "Trouble" OR "Question" OR "Snag" OR "Obstacle" OR "Hurdle" OR "Hitch" OR "Stumbling Block" OR "Obstruction" OR "Case" OR "Knot" OR "Matter" OR "Nut" OR "Problem" OR "Defiance" OR "Gantlet" OR "Provocation" OR "Dare" OR "Stump" OR "Risk" OR "Barrier" OR "Confront" OR "Defy" OR "Face up to" OR "Dispute")*

<u>Result for c</u>

RQ:

Global Software Development: *("GSD"OR "Global Software Engineering" OR "GSE" OR "Distributed Software Development" OR "DSD" OR "Multisite Software Development" OR "Outsourcing")*

Organization*: ("Vendor" OR "Developer" OR "Provider" OR "Team")*

Social Computing*: ("Social Networks" OR "Social Media" OR "Social Interactions" OR "Social Communities" OR "Virtual Communities")*

Adoption: *("Adopting" OR "Acceptance" OR "Implementation" OR "Approval" OR "Agreement)*

Challenge*: ("Issue" OR "Trouble" OR "Problem" OR "Risk" OR "Barrier")*

Result for d

RQ:

("Global software development" OR "GSD" OR "Global Software Engineering" OR "GSE" OR "Distributed Software Environment" OR "DSD") AND ("Organization" OR "Vendor" OR "Developer" OR "Provider" OR "Team")AND ("Social computing" OR "Social Media") AND ("Adoption" OR "Adopting" OR "Acceptance" OR "Implementation" OR "Approval" OR "Agreement))AND("challenge" OR "issue " OR "Trouble" OR "Problem" OR "Risk" OR "Barrier")

The final combined search strings are shown in the next Figures 5-10.

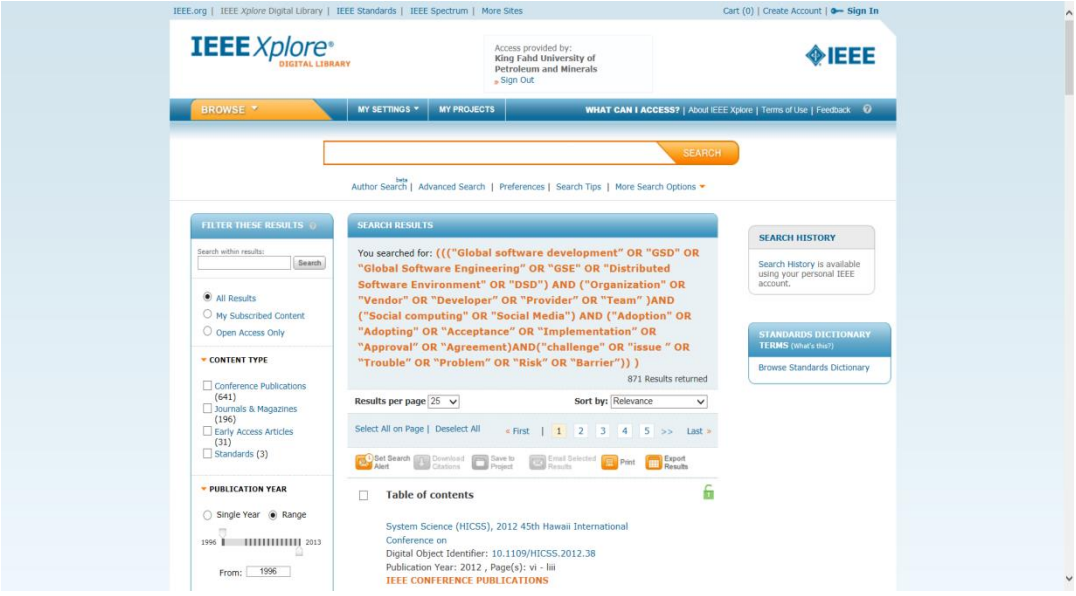


Figure 5 IEEEXplore Results

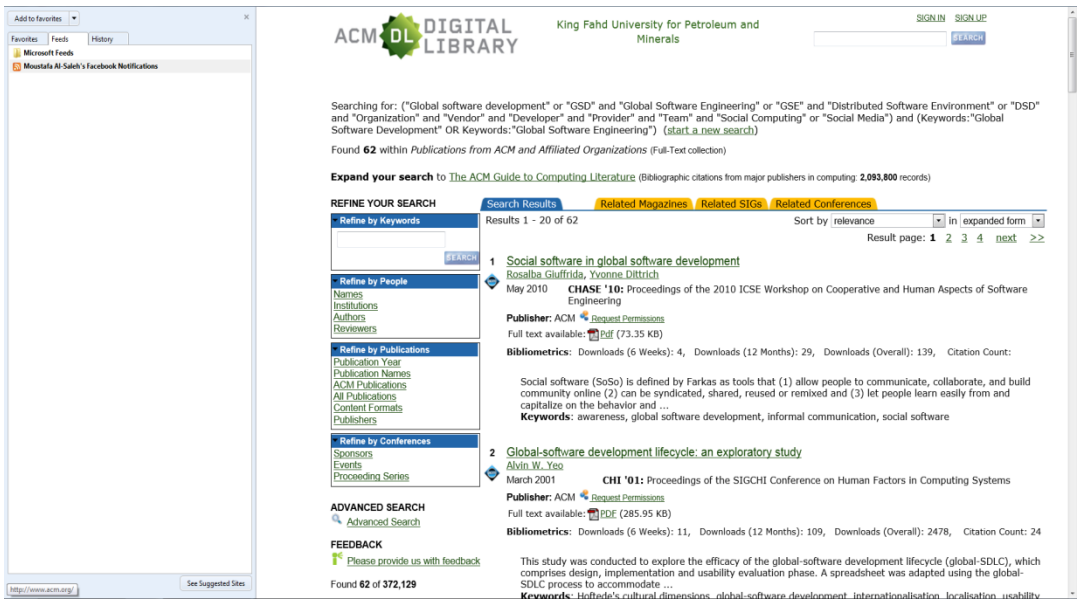


Figure 6 ACM Results

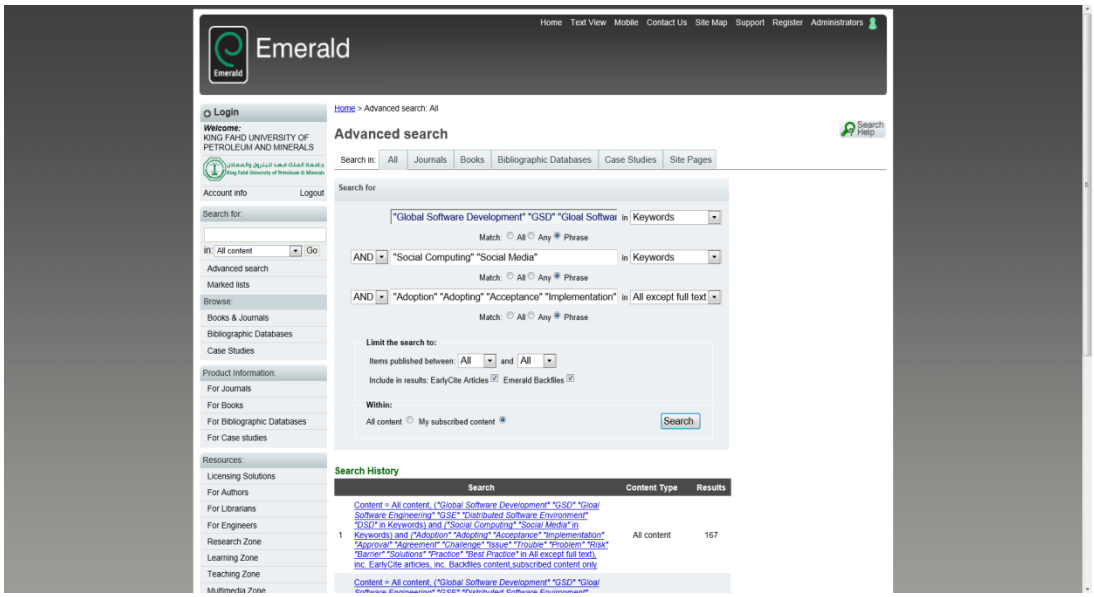


Figure 7 Emerald Results

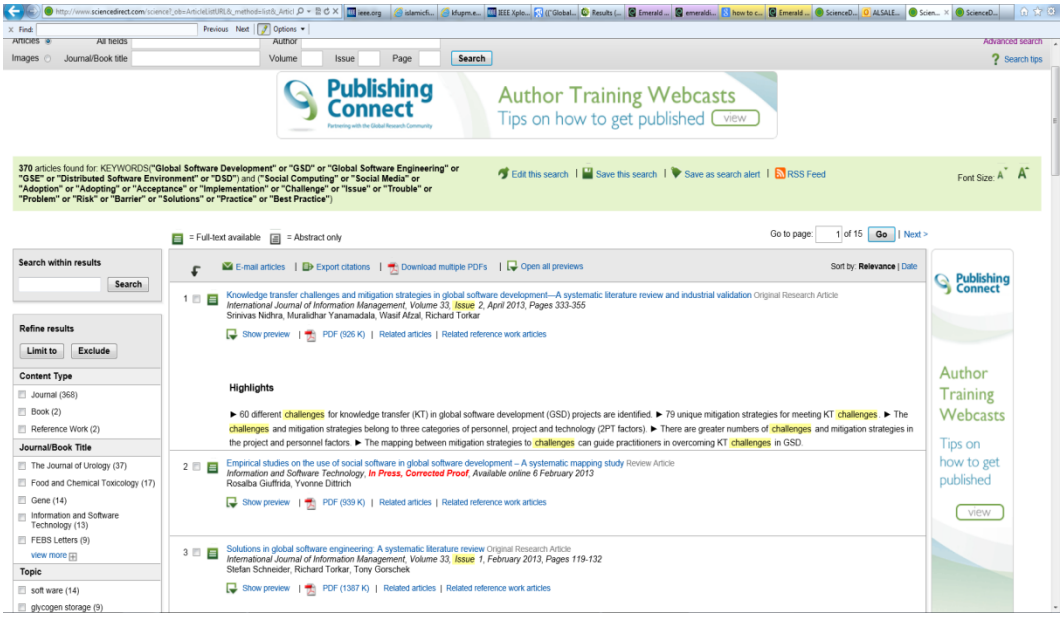


Figure 8 ScienceDirect Results

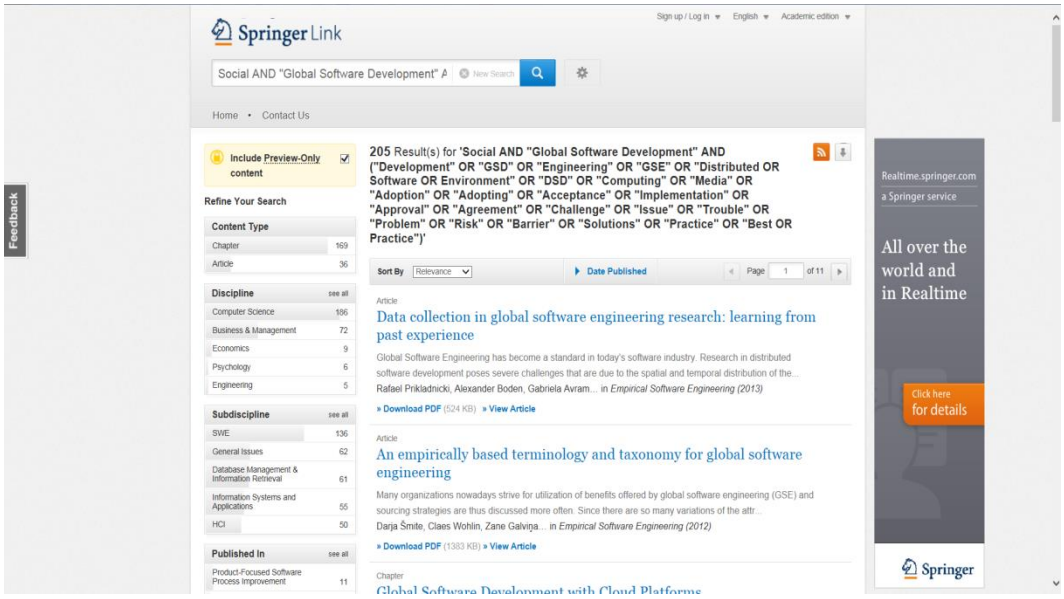


Figure 9 SpringerLink Results

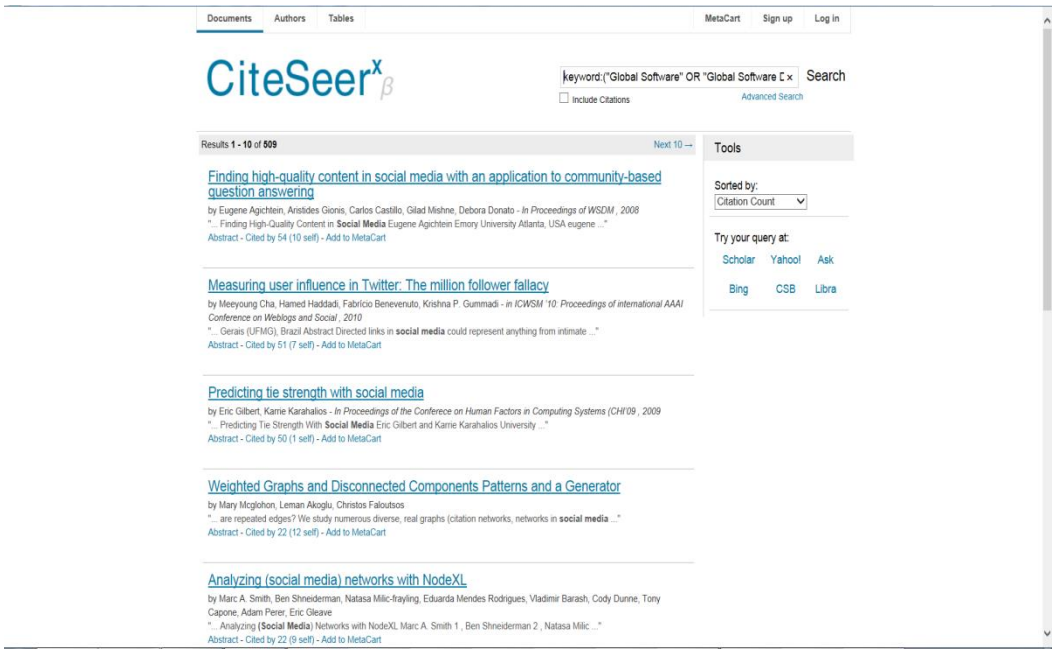


Figure 10 CiteSeer Results

3.1.2 Publication Selection

3.1.2.1 Inclusion Criteria

The inclusion criteria we have identified to determine which part of literature returned by the search string would be used for data extraction

- Studies that are reported in English language only.
- Studies published in any of the key researcher or specialized conference or workshop mentioned in the secondary resources.
- Studies that related the social computing tools and activities to the global software development processes.
- Studies that identified the challenges and issues of adopting social media in software development.
- Studies focus on enhancing collaboration, communication or productivity.
- Studies foresee the future of social computing tools in aiding software projects.

3.1.2.2 Exclusion Criteria

- Studies those are not relevant to the research questions.
- Studies with poor English are excluded as the sentences may cause ambiguity or exposes conflicts of ideas.
- Graduation Projects, Mater thesis and PhD Dissertation are excluded as they tend to be much focused and there is no evidential proof of any review.
- Books whether in print or electronic are excluded from this systematic review.
- Studies conducted in other than global software development and social computing environment e.g. talking about in-house software development or other kind of global projects i.e. not software development project.

- Studies those describe global software development processes only.
- Studies those describe social computing without defining the relationships to the software development.
- Implementation papers of collaboration tools are rejected unless it's complemented by a justifiable analysis of how these tools may aid global software development.
- Studies that don't define challenges or issues emerge from social computing adoption through software development.
- Studies related to psychology or pure motivations related to employees are rejected as these papers are focused on the driving factors of business firm not individual employees.
- Studies that show adoption of collaboration tools in a single department or in a small project are rejected as they are not the purpose of this study.
- Studies whose focus is social computing for the education purposes.

3.1.3 Selecting Primary Sources

The selection process had mainly two phases as planned in the review protocol: an initial selection from the search results based on reading the title and the abstract of the paper; then by final selection from the first step by reading the full paper. These processes are depicted in Figure 11.

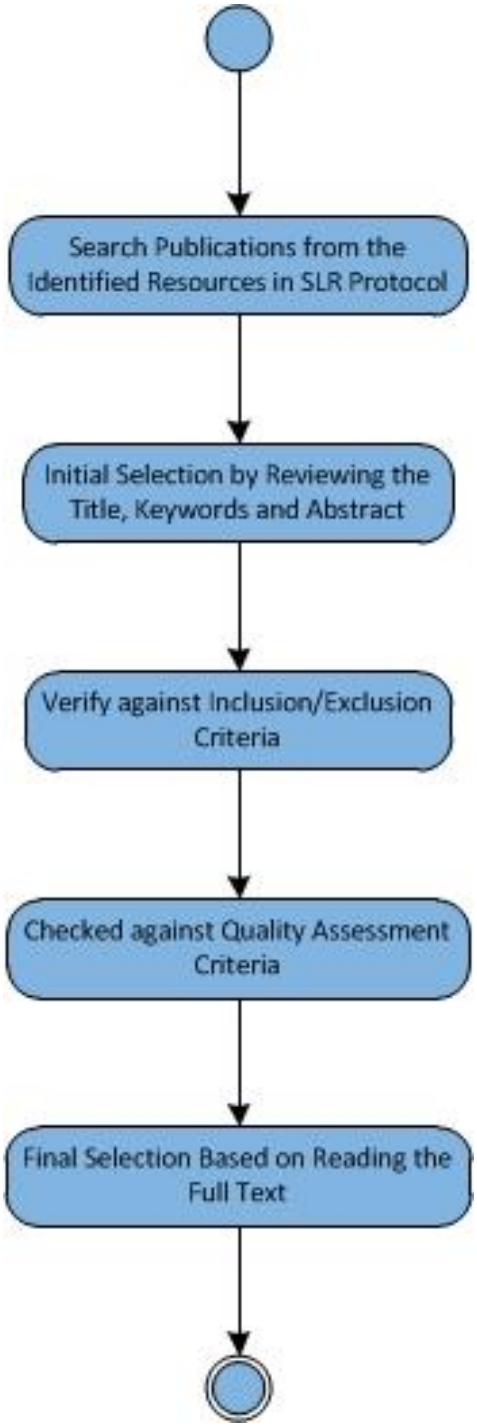


Figure 11 Processes of Selecting Primary Resources

Forty-one primary studies have been selected to this review. Table 3 below summarizes the search strategy and phases.

Table 3 Primary studies selection from different resources

Resource	Total Results Found	Initial Selection	Final Selection
IEEEXplore	871	176	18
ACM	62	36	11
SpringerLink	205	20	5
ScienceDirect	370	17	5
Emerald	167	21	1
CiteSeer	509	5	1
Total			**41**

3.1.4 Quality Assessment

The quality assessment has been performed after we finished the final selection of publications; the quality checklists included the following questions as shown in Table 4.

Table 4 Quality assessment

Item	Criteria	Score between 0 – 1	Response options for Score
1.	Does study report clear, unambiguous findings based on evidence and argument?		Yes = 1 /No = 0
2.	Is there any empirical evidence on the findings?		Yes = 1 /No = 0
3.	Are the challenges of using the social computing tools in GSD project well identified?		Yes = 1 Moderately = 0.5 No = 0
4.	Is it clear how the social computing tools have been used in the GSD project?		Yes = 1 Moderately = 0.5 No = 0
5.	Is the author seems biased to publish positive results more than negative results?		Yes = 0 No = 1
6.	Could you replicate study?		Yes = 1 No = 0
7.	Are the arguments well- presented and justified?		Yes = 1 Moderately = 0.5 No = 0
8.	Is the paper well/appropriately Referenced?		Yes = 1 Moderately = 0.5 No = 0

3.1.5 Data Extraction

This review was performed by a single researcher, who was alone responsible for data extraction. A secondary reviewer was approached for guidance in case of an issue regarding the data extraction. The following data has been extracted from each publication: Title, Author, Date of review, Reference, Database, Social computing tool and, Challenges as shown in Table 5.

Table 5 Data extraction

Extracted Data	Description
Title	
Author	
Date of Review	
Reference	
Database	
Study Type	
Social Computing Tool/Concept/Platform	
Challenges	

3.1.6 Data Synthesis

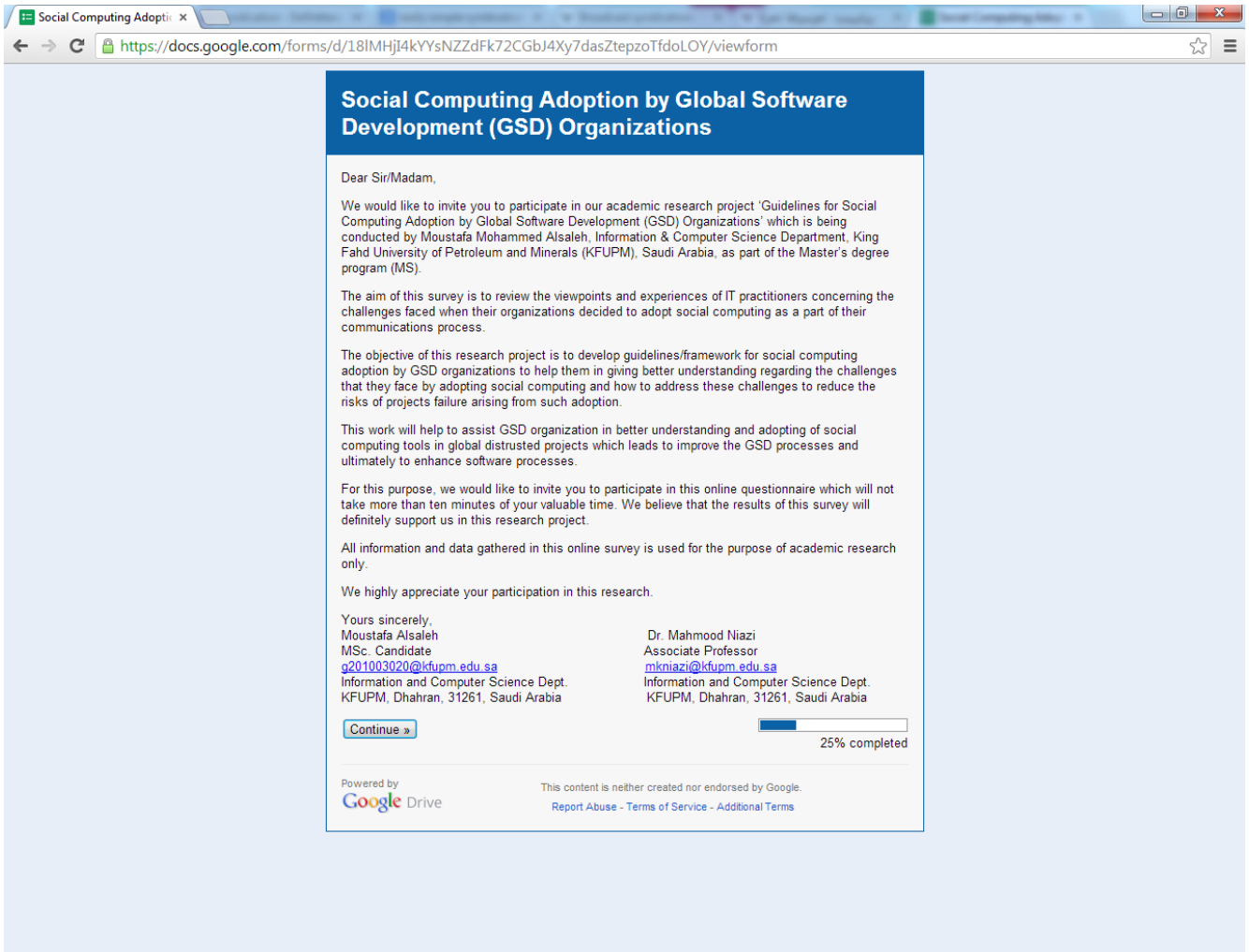
Due to the nature of the research questions we are going to synthesis the extracted data by checking the most frequent challenge that faces the GSD organizations in using social media, the most frequent challenge has the highest impact. This categorization will help us in defining the challenges with higher priorities which may hinder the project or may lead the project to fail.

In addition to this, we are going to analyse studies based on the countries where it has been conducted, this will give us good perception if there is a correlation between the country and the challenge identified.

Nevertheless, we are going to investigate the study types by the identified primary studies in SLR and if there is a correlation between the study type and the challenges pointed out in this study.

3.2 Questionnaire Design

Based on the results we have extracted from the SLR, we have validated these results by creating an online questionnaire targeting the IT practitioners and software developers in the GSD industry. The questionnaire has been developed using Google Docs (https://docs.google.com) service which is a free online service and has many advantages of usability and accessibility to the targeted samples. The population of targeted samples was approximately around 250 practitioners and the response percentage was above 31% overall the candidates, see Figure 12.



Social Computing Adopti

https://docs.google.com/forms/d/18lMHjI4kYYsNZZdFk72CGbJ4Xy7dasZtepzoTfdoLOY/viewform

Social Computing Adoption by Global Software Development (GSD) Organizations

Dear Sir/Madam,

We would like to invite you to participate in our academic research project 'Guidelines for Social Computing Adoption by Global Software Development (GSD) Organizations' which is being conducted by Moustafa Mohammed Alsaleh, Information & Computer Science Department, King Fahd University of Petroleum and Minerals (KFUPM), Saudi Arabia, as part of the Master's degree program (MS).

The aim of this survey is to review the viewpoints and experiences of IT practitioners concerning the challenges faced when their organizations decided to adopt social computing as a part of their communications process.

The objective of this research project is to develop guidelines/framework for social computing adoption by GSD organizations to help them in giving better understanding regarding the challenges that they face by adopting social computing and how to address these challenges to reduce the risks of projects failure arising from such adoption.

This work will help to assist GSD organization in better understanding and adopting of social computing tools in global distrusted projects which leads to improve the GSD processes and ultimately to enhance software processes.

For this purpose, we would like to invite you to participate in this online questionnaire which will not take more than ten minutes of your valuable time. We believe that the results of this survey will definitely support us in this research project.

All information and data gathered in this online survey is used for the purpose of academic research only.

We highly appreciate your participation in this research.

Yours sincerely,

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Figure 12 Questionnaire Page

The questionnaire was divided mainly into three parts. The first part was to collect personal information about the participant, the second part was a demographical part about the participant's organization and, finally the third part surveyed the opinions of the participants if they agreed to the identified challenges or disagreed.

3.2.1 Questionnaire Section One (Practitioner's Details)

Full Name (optional)		Job Title / Position	
Experience (in years) Your experience in software outsourcing relevant jobs in current/previous organisations.			
Country			
Email Address (optional)			
Telephone (optional)			

3.2.2 Questionnaire Section Two (Demographics)

1. Company's country in which it is located?			
Please specify:			
2. What is the primary business function of your company? (you may tick more than one)			
In-house development ☐		Outsource Development ☐	
Other ☐ *Please specify*:			
3. What is the scope of your company? (please tick as appropriate)			
National ☐	Multinational ☐	Don't know ☐	
Other ☐ Please specify:			
4. Approximately how may staff are employed by your company? (please tick as appropriate)			
Less than 20 ☐	20-199 ☐	Greater than 200 ☐	Not Sure ☐

5. Approximately how may staff are employed directly in the production/maintenance of software? (please tick as appropriate)

Less than 20 ☐	20-199 ☐	Greater than 200 ☐	Not Sure ☐

6. What type of systems are your company concerned with? (You may tick more than one)	
Safety critical ☐	Data processing ☐
Business systems ☐	Systems software ☐
Telecommunications ☐	Windows based ☐
Real-time systems ☐	Embedded systems ☐
Other ☐ *Please specify*:	
7. Which social computing tool is being used by your organization/company? (You may choose more than one)	
Instant Messaging ☐	Blogs ☐
Wiki-like tools ☐	Bookmarks and Tagging ☐
Voice over IP (For Example: Skype) ☐	In-house Developed tools ☐
Profile-based social networks (For Example: Twitter, LinkedIn) ☐	
Other ☐ *Please specify*:	

3.2.3 Section Three (Identified Challenges through SLR)

Please **cross** the appropriate box based on your experience of using social computing tools

Challenges	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**	**Not Sure**
1- Miscommunication *Miscommunication among virtual team members are due to: language, cultural, organizational, and political differences.*	☐	☐	☐	☐	☐
2- Organization structure and policy *Lack of procedures and policies for the use of social communication tool in GSD at the organizational level.*	☐	☐	☐	☐	☐
3- Knowledge management *Creating, managing and sharing information via social computing tools.*	☐	☐	☐	☐	☐

4- Multiple communication channels *Managing the use of multiple social computing communication tools and channels.*	☐	☐	☐	☐	☐
5- Limitations of social computing tools *Limitations of social computing tools such as keeping communication history.*	☐	☐	☐	☐	☐
6- Trust and privacy *Lack of trust and privacy in information sharing.*	☐	☐	☐	☐	☐
7- Social computing tool availability *The lack of availability of appropriate social computing tools for GSD.*	☐	☐	☐	☐	☐
8- Lack of motivation to use social computing *Lack of motivation to use social computing due to lack of critical mass & little or no perceived return on investment.*	☐	☐	☐	☐	☐
9- Immediacy of feedback *Lack of immediate feedback.*	☐	☐	☐	☐	☐
10- Alignment with the developers' practices *Social computing tools alignment with the developers' practices such as modelling, coding, and debugging.*	☐	☐	☐	☐	☐
11- Security *Security of information being transferred through the social media.*	☐	☐	☐	☐	☐
12- Social computing tool familiarity *The lack of familiarity for using the social computing tools.*	☐	☐	☐	☐	☐

CHAPTER 4

RESULTS AND ANALYSIS

4.1 Systematic Literature Review (SLR) Results

Our findings are based on the definition of the challenges of social computing adoption by GSD organizations. We have mapped the extracted challenges from the selected primary studies and checked if the extracted data was in a compliance with the challenge definition we proposed or not and if so then we have included the extracted challenge, otherwise, we rejected it.

One hundred-forty challenges were identified through data extraction process. These challenges have been categorized mainly into twelve main categories. Table 6 shows each challenge category and its own references. (For further details of these challenges please see Appendix A)

Table 6 SLR Results

No.	Challenge	Reference	Frequency
1.	**Miscommunication** *Miscommunication among virtual team members are due to: language, cultural, organizational, and political differences.*	[30] [44] [51] [78] [95] [96] [97] [98] [99] [100] [101] [102] [103] [104] [105] [106] [107] [108] [109] [110] [111]	21
2.	**Organization structure and policy** *Lack of procedures and policies for the use of social communication tool in GSD at the organizational level.*	[41] [51] [88] [95] [99] [100] [102] [103] [106] [107] [111] [112] [113] [114] [115] [116] [117] [118]	18
3.	**Knowledge management** *Creating, managing and sharing information via social computing tools.*	[41] [44] [83] [95] [96] [97] [101] [102] [104] [105] [107] [112] [116] [118] [119]	15
4.	**Multiple communication channels** *Managing the use of multiple social computing communication tools and channels.*	[51] [89] [96] [100] [101] [103] [106] [110] [111] [113] [116] [117] [118] [120] [121]	15
5.	**Limitations of social computing tools** *Limitations of social computing tools such as keeping communication history.*	[29] [51] [78] [89] [97] [100] [102] [103] [108] [110] [113] [121] [122] [123]	14
6.	**Trust and privacy** *Lack of trust and privacy in information sharing.*	[44] [61] [88] [95] [96] [102] [105] [106] [112] [119] [122] [124]	12
7.	**Social computing tool availability** *The lack of availability of appropriate social computing tools for GSD.*	[51] [61] [98] [99] [100] [102] [106] [109] [117] [121] [125]	11
8.	**Lack of motivation to use social computing** *Lack of motivation to use social computing due to lack of critical*	[30] [61] [88] [89] [99] [103] [109] [110] [114] [119]	10

	mass & little or no perceived return on investment.		
9.	**Immediacy of feedback** *Lack of immediate feedback.*	[97] [98] [100] [101] [107] [111] [116] [121]	8
10.	**Alignment with the developers' practices** *Social computing tools alignment with the developers' practices such as modelling, coding, and debugging.*	[29] [61] [78] [89] [103] [112]	6
11.	**Security** *Security of information being transferred through the social media.*	[88] [103] [106] [112] [119] [124]	6
12.	**Social computing tool familiarity** *The lack of familiarity for using the social computing tools.*	[78] [102] [109] [121] [125]	5
Total			**140**

4.1.1 SLR Frequency Analysis

Table 7 SLR Frequency Analysis

Challenge	Frequency	Percentage (n=41)
Miscommunication	**21**	**51.2%**
Organization structure and policy	**18**	**43.9%**
Knowledge management	15	36.6%
Multiple communication channels	15	36.6%
Limitations of social computing tools	14	34.1%
Trust and privacy	12	29.3%
Social computing tool availability	11	26.8%
Lack of motivation to use social computing	10	24.4%
Immediacy of feedback	8	19.5%
Alignment with the developers' practices	6	14.6%
Security	**6**	**14.6%**
Social computing tool familiarity	**5**	**12.2%**

Table 7 depicts the frequency distribution of various challenges as cited in the literature. 'Miscommunication' and 'Organization structure and policy' cited the most with 51.2% and 43.9% respectively. 'Miscommunication' is well-known issue in GSD and it has been assumed that social media is adopted to solve this issue basically. However, it seems the media is still immature and there is a long way to replace face-to-face communication or physical presence due to the difficulty of capturing non-verbal communication or sensing the communicator's mood.

Social computing is inherently informal and unstructured. GSD usually involves tasks distributed among different organizations which exhibit divergent structure and policies. Owing to the aforementioned peculiarities, ‘Organization structure and policy’ places the second in the table.

‘Security’ and ‘Social computing tool familiarity’ ranked the lowest in the list with only 14.6% and 12.2% respectively of literature cited them. It’s clear that security has been an issue of adopting social computing for longer time. However, recent new articles have been investigating other challenges and as such most of the recent papers wouldn’t mention security as much as before. Familiarity also receives little attention in the literature due to the wide acceptance and use of many social computing technologies. Nowadays, Most of the people are using one or more social computing tools in their day-to-day activities.

4.1.2 SLR Study Type Analysis

Table 8 Study Types

Challenges	Case Study (n=13)	Interview (n= 9)	Literature Review (n= 8)	Experience Report (n= 2)	Survey (n= 0)	Other (n=9)	Total
Miscommunication	38%	10%	24%	5%	0%	24%	100%
Organization structure and policy	22%	28%	33%	0%	0%	17%	100%
Knowledge management	**40%**	13%	20%	**13%**	0%	13%	100%
Multiple communication channels	13%	**40%**	27%	0%	0%	20%	100%
Limitations of social computing tools	29%	29%	14%	0%	0%	29%	100%
Trust and privacy	25%	8%	**42%**	8%	0%	17%	100%
Social computing tool availability	18%	36%	27%	0%	0%	18%	100%
Lack of motivation to use social computing	**40%**	10%	30%	0%	0%	20%	100%
Immediacy of feedback	38%	25%	13%	0%	0%	25%	100%
Alignment with the developers' practices	17%	17%	17%	0%	0%	**50%**	100%
Security	40%	0%	20%	0%	0%	40%	100%
Social computing tool familiarity	20%	20%	20%	0%	0%	40%	100%

Table 8 links the challenges identified via SLR with the strategy type. Four main strategy types have been identified namely: Case Study, Interview, Literature Review and, Experience Report. In addition, some articles that can't be clearly classified with the above categories are placed in 'Other' category and the count of these articles is 9. 'Other' category mainly includes articles that develop a new tool, evaluate it and demonstrate it. Furthermore, none of the papers collected can be classified as Survey paper.

‘Knowledge Management’, ‘Lack of motivation to use social computing’ and ‘Security’ are cited the most 40% by case study articles. ‘Multiple communications channels’ cited the most 40% by interview articles. ‘Trust and privacy’ cited the most 42% by literature review articles; this is not surprising since privacy has been a traditional challenge of adopting social computing tool and most of the articles which discuss the emergence of social computing and its impact acknowledged the challenge of trust and privacy. Experience reports; however cited ‘Knowledge Management’ the most with 13%. In ‘Other’ category, ‘Alignment with the developers practice’ cited the most with 50%. Since most of the other categories are discussing tools and their uses, alignment with the developer practice sound the most notable challenge in these papers.

4.1.3 SLR Continent Analysis

Table 9 SLR Continent Analysis

Challenges	North America (n=19)	Europe (n= 19)	Other (n= 3)	Total
Miscommunication	33%	53%	14%	100%
Organization structure and policy	33%	56%	11%	100%
Knowledge management	54%	33%	13%	100%
Multiple communication channels	47%	47%	6%	100%
Limitations of social computing tools	29%	**71%**	0%	100%
Trust and privacy	**58%**	25%	**17%**	100%
Social computing tool availability	36%	55%	9%	100%
Lack of motivation to use social computing	50%	50%	0%	100%
Immediacy of feedback	25%	62%	13%	100%
Alignment with the developers' practices	50%	50%	0%	100%
Security	50%	33%	**17%**	100%
Social computing tool familiarity	40%	60%	0%	100%

Table 9 illustrates the various challenges as identified in articles produced by authors from various continents. There are 19 articles are written by authors from North America. Similarly, another 19 from Europe while a small amount of three papers are from other continents. 'Trust and privacy' cited the most by 'North America' articles with 58%. 'Limitation of social computing tools' cited the most by 71% of European articles. For other category, 'Trust & privacy' and 'Security' ranked as the most cited challenge with 17%.

4.2 Questionnaire Analysis

4.2.1 Questionnaire Frequency Analysis

Table 10 Questionnaire frequency analysis

Challenges	Responses (n=78)							
	Positive			Negative			Neutral	
	Strongly Agree	Agree	Percentage	Disagree	Strongly Disagree	Percentage	Not sure	Percentage
Miscommunication	19	47	**84.6%**	9	2	14.1%	1	1.3%
Organization structure and policy	16	44	76.9%	9	3	15.4%	6	7.7%
Knowledge management	23	43	**84.6%**	5	1	7.7%	6	7.7%
Multiple communication channels	21	39	76.9%	9	3	15.4%	6	7.7%
Limitations of social computing tools	16	36	66.6%	14	5	24.4%	7	9.0%
Trust and privacy	24	34	74.3%	16	3	24.4%	1	1.3%
Social computing tool availability	16	40	71.8%	18	1	24.4%	3	3.8%
Lack of motivation to use social computing	13	37	64.1%	17	3	25.6%	8	10.3%
Immediacy of feedback	15	32	60.3%	26	2	**35.9%**	3	3.8%
Alignment with the developers' practices	13	42	70.6%	11	3	17.9%	9	11.5%
Security	27	35	79.5%	12	4	20.5%	0	**0.0%**
Social computing tool familiarity	15	37	66.7%	17	6	29.5%	3	3.8%

Table 10 shows the frequency distribution of 78 responses obtained from our online questionnaire. They are divided into three categories: Positive, Negative and Neutral. Positive indicates that the respondent agrees that a particular challenge hinder the adoption of social computing technology in GSD environment. Negative indicates that the respondent is contradicting the hypothesis that a certain challenge is actually a

challenge. Neutral indicates the user can't evaluate the impact of a particular challenge on the adoption of social computing in GSD projects.

The table shows that all mentioned challenges in our questionnaire receive high positive percentages greater than 60%. 'Miscommunication' and 'Knowledge management' 84.6% ranked the first as the most agreeable challenge by our respondents. Miscommunication is a common issue in global software settings and it's evident that social computing is realized to mitigate the risk of miscommunication. Nevertheless, it seems our respondents are still convinced that miscommunication issue is large and takes many dimensions and social computing environment will not solve the challenge ultimately. Knowledge management is a serious challenge in any organization despite its size. The process of capturing, processing, storing and retaining knowledge have been studied extensively in the literature. Industrial people are aware of the significance of this challenge and thus it was cited the most, side by side, with miscommunication.

'Immediacy of feedback' ranked the first (35.9%) as the top negative response. It indicates that around 36% of respondents don't perceive 'Immediacy of feedback' as a challenge. It should be noted that the target audience of this software are IT personnel who are very ambitious to utilize any emerging technology. We can argue that IT people are more trained in reducing the disturbance caused by these tools.

'Security' is the only challenge that none of the respondents answers it with 'Not sure', security has been a traditional issue associated with the internet and it's still a major issue. It's of no surprise to infer that all respondents have heard, involved or

experienced a security issue either in their job or at their home. That's account for the 100% of feedback for this challenge.

4.2.2 Age Questionnaire Analysis

Table 11 Age Questionnaire Analysis

Challenges	Positive '25-34' (n=54)	Percentage	Positive '35-44' (n =19)	Percentage	Positive 'Other' (n= 5)	Percentage
Miscommunication	47	**87%**	15	**79%**	4	80%
Organization structure and policy	45	83%	13	68%	4	80%
Knowledge management	45	83%	15	**79%**	3	60%
Multiple communication channels	40	74%	15	**79%**	3	60%
Limitations of social computing tools	41	76%	11	58%	3	60%
Trust and privacy	37	69%	14	74%	3	60%
Social computing tool availability	42	78%	10	53%	4	80%
Lack of motivation to use social computing	43	80%	9	47%	3	60%
Immediacy of feedback	35	65%	11	58%	3	60%
Alignment with the developers' practices	44	81%	13	68%	1	20%
Security	39	72%	14	74%	5	**100%**
Social computing tool familiarity	40	74%	13	68%	1	20%

Table 11 shows the number of respondents belonging to different age groups who agree on a particular challenge.

Three major groups have been identified in this analysis: respondents whose age is between (25-34) years old, (35-44) years old and (Other). We obtained 54 response from the first group, 19 from the second group and 5 in the 'Other' category. 'Other' age group include those who are (below 25), (45-54), (55-64) and (over 65 years) old.

Respondents are between (25-34) years old cited 'Miscommunication' with 87%. Whereas, 'Miscommunication', 'Knowledge management', and 'Multiple communication channels' cited the most 79% by respondents whose ages fall within (35-44). 'Security' was cited again as the top challenge 100% by respondents fall within 'Other' category whose majority are staff older than 44 years old.

It's evident that senior staff (44 and above) who have many years of experience fear 'Security' challenge the most since they observe many events where some business secrets have been leaked out and some of their security parameters have been preached by malicious software. 'Alignment with the developer's practice' and 'Social computing familiarity' are the least cited challenge 20% in the 'Other' category. 'Trust and privacy' however, is the least cited challenge among (25-34) years old group. For respondents of age (35-44), 'Social computing tool availability' is ranked at the bottom with only 53%.

4.2.3 Gender Questionnaire Analysis

Table 12 Gender questionnaire analysis

Challenges	Positive 'Male' (n= 62)	Percentage	Positive 'Female' (n=16)	Percentage
Miscommunication	51	82%	15	**94%**
Organization structure and policy	47	76%	13	81%
Knowledge management	54	**87%**	12	75%
Multiple communication channels	50	81%	10	63%
Limitations of social computing tools	39	63%	13	81%
Trust and privacy	44	71%	14	88%
Social computing tool availability	43	69%	13	81%
Lack of motivation to use social computing	38	61%	12	75%
Immediacy of feedback	35	56%	12	75%
Alignment with the developers' practices	43	69%	12	75%
Security	47	76%	15	**94%**
Social computing tool familiarity	44	71%	8	50%

Table 12 shows the view of a particular challenge according to the gender of the respondent. We have obtained 62 responses from 'Male' group and the remaining are from 'Female' group. 'Knowledge management' was cited the most 87% by 'Male', whereas 'Miscommunication' and 'Security' ranked the first by 'Female' group 94%.

The least cited challenge by 'Male' is 'Immediacy of feedback' 56% while 50% of 'Female' respondents selected 'Social computing tool familiarity'.

By correlating the results of 'Male' and 'Female' percentage columns, the correlating value is approximately 0.1.Clearly; there is no strong evidence that correlates gender groups to the list of challenges.

4.2.4 Organization Size Questionnaire Analysis

Table 13 Organization Size Questionnaire Analysis

Challenges	Positive 'Small Size' (n= 3)	Percentage	Positive 'Medium Size' (n=13)	Percentage	Positive 'Large Size' (n=61)	Percentage	Positive 'Not Sure' (n=1)	Percentage
Miscommunication	2	67%	11	**85%**	53	**87%**	0	0%
Organization structure and policy	3	**100%**	9	69%	48	79%	0	0%
Knowledge management	3	**100%**	10	77%	52	85%	1	100%
Multiple communication channels	3	**100%**	10	77%	46	75%	1	100%
Limitations of social computing tools	1	33%	9	69%	41	67%	1	100%
Trust and privacy	2	67%	8	62%	47	77%	1	100%
Social computing tool availability	3	**100%**	8	62%	45	74%	0	0%
Lack of motivation to use social computing	3	**100%**	7	54%	39	64%	1	100%
Immediacy of feedback	3	**100%**	5	38%	39	64%	0	0%
Alignment with the developers' practices	2	67%	9	69%	43	70%	1	100%
Security	2	67%	10	77%	49	80%	1	100%
Social computing tool familiarity	2	67%	11	**85%**	39	64%	0	0%

Table 13 shows the frequency of responses according to the company's size. Three categories of company size have been determined: 'Small' (less than 20 staff), 'Medium' (20-199), 'Large' (Greater than 200). Out of 78 responses collected, 3 respondents belong to small company's size, 13 to 'Medium' and 61 to 'Large'. Only one respondent is not sure about his organization size. The high number of respondents in the large group is anticipated since our focus is on global projects which usually involve multinational companies with offices spread around the globe.

Our results show that all challenges have received positive responses from all groups 'Small', 'Medium' and 'Large'. Due to the fact that the majority of respondents are working in large organizations, all challenges receive higher frequency in 'Large' group. Moreover, the 'Not Sure' category is not going to be analysed due to the low density in this group and can be safely ignored.

For 'Small' organization, six challenges share the top ranks: 'Organization Structure and policy', 'Knowledge management', 'Multiple communication channels', 'Social computing tool availability', 'Lack of motivation to use social computing' and 'Immediacy of feedback'. Each one of the aforementioned challenges has been cited by 100% of the respondents. One challenge cited the least in 'Small' group which is: 'Limitations of social computing tool' with 33%.

For 'Medium' organizations, 'Miscommunication' and 'Social computing tool familiarity' obtained 85% which is the highest percentage. 'Immediacy of feedback' cited the least with only 38%. For 'Large' organization category, 'Miscommunication' cited

with 87% and 'Security' cited with 67% and these are the top challenges cited by respondents within this group. It's evident in large organizations that communication breaks down more often and due to differences in culture, language and expertise, there is the chance of ambiguity, confusion and miscommunication.

4.2.5 Experience Level Questionnaire Analysis

Table 14 Experience Level Questionnaire Analysis

Challenges	Positive of 'Junior' (n= 35)	Percentage	Positive of 'Intermediate' (n=27)	Percentage	Positive of 'Senior' (n=12)	Percentage
Miscommunication	33	94%	21	78%	11	92%
Organization structure and policy	25	71%	13	48%	7	58%
Knowledge management	24	69%	15	56%	6	50%
Multiple communication channels	21	60%	13	48%	7	58%
Limitations of social computing tools	20	57%	11	41%	5	42%
Trust and privacy	15	43%	12	44%	9	75%
Social computing tool availability	22	63%	12	44%	9	75%
Lack of motivation to use social computing	16	46%	14	52%	6	50%
Immediacy of feedback	18	51%	9	33%	5	42%
Alignment with the developers' practices	25	71%	11	41%	7	58%
Security	22	63%	15	56%	5	42%
Social computing tool familiarity	19	54%	13	48%	6	50%

Table 14 shows the distribution of responses according to the experience of the respondents. Respondents are categorized into three categories with respect to their

experience: ‘Junior’ who usually has 5 years of experience or less, ‘Intermediate’ who usually have more than 5 years of experiences but less or equal to 10 years of experience, and ‘Senior’ respondents are those who have more than 10 years of industrial experience. In ‘Junior’ category, we have 35 respondents, in ‘Intermediate’ category we have 27 respondents and 12 respondents are ‘Senior’. In addition, 2 respondents have been excluded due to their improper answer.

‘Miscommunication’ was the dominated challenge cited by all groups ‘Junior’, ‘Intermediate’ and ‘Senior’ with 94%, 78% and 92 % respectively. ‘Junior’ group cited ‘Trust and privacy’ as the least challenge with only 43%. We can argue that junior staff belongs to the newer generation who is using social computing tools extensively in their regular life and as such the issue of trust and privacy is fading in their perspective. Surprisingly, ‘Immediacy of feedback’ was the least cited challenge among ‘Intermediate’ and ‘Senior’ staff with 33% and 42% respectively. It is possible that experienced staffs are less distracted to social computing tools and they have a competent skill in time management.

4.3 Correlation Analysis

In order to quantify the significance of the similarity in the challenges identified via SLR and questionnaire-based empirical study, we performed a correlation analysis test. Tables 15 and 16 show the ranks of challenges and Spearman's rank correlation respectively. Spearman's rank correlation coefficient is 0.582 whereas p=0.047. The p value (i.e., 0.047) shows that there is a substantial similarity between the results obtained from the two data sets SLR and the questionnaire.

Figure 13 shows the distribution of SLR and questionnaire ranks. The distribution shows a strong correlation where an increasing value of the rank of SLR is followed by an increasing value of questionnaire rank in most cases. This illustrates clearly the results obtained from Spearman's rank correlation as in Table 16.

Table 15 Correlation Analysis

Challenges	Occurrence in SLR (n=41)		'Positive' Questionnaire (n=78)		Average Rank
	Frequency	Rank	Frequency	Rank	
Miscommunication	21	1	66	1	1
Organization structure and policy	18	2	60	4	3
Knowledge management	15	3	66	1	2
Multiple communication channels	15	3	60	4	4
Limitations of social computing tools	14	5	52	9	7
Trust and privacy	12	6	58	6	6
Social computing tool availability	11	7	56	7	7
Lack of motivation to use social computing	10	8	50	11	10
Immediacy of feedback	8	9	47	12	11
Alignment with the developers' practices	6	10	55	8	9
Security	6	10	62	3	7
Social computing tool familiarity	5	12	52	9	10

Table 16 Spearman's Rank Correlation Coefficient

Correlations

			SLR	Questionnaire
Spearman's rho	SLR	Correlation Coefficient	1.000	.582*
		Sig. (2-tailed)	.	.047
		N	12	12
	Questionnaire	Correlation Coefficient	.582*	1.000
		Sig. (2-tailed)	.047	.
		N	12	12

*. Correlation is significant at the 0.05 level (2-tailed).

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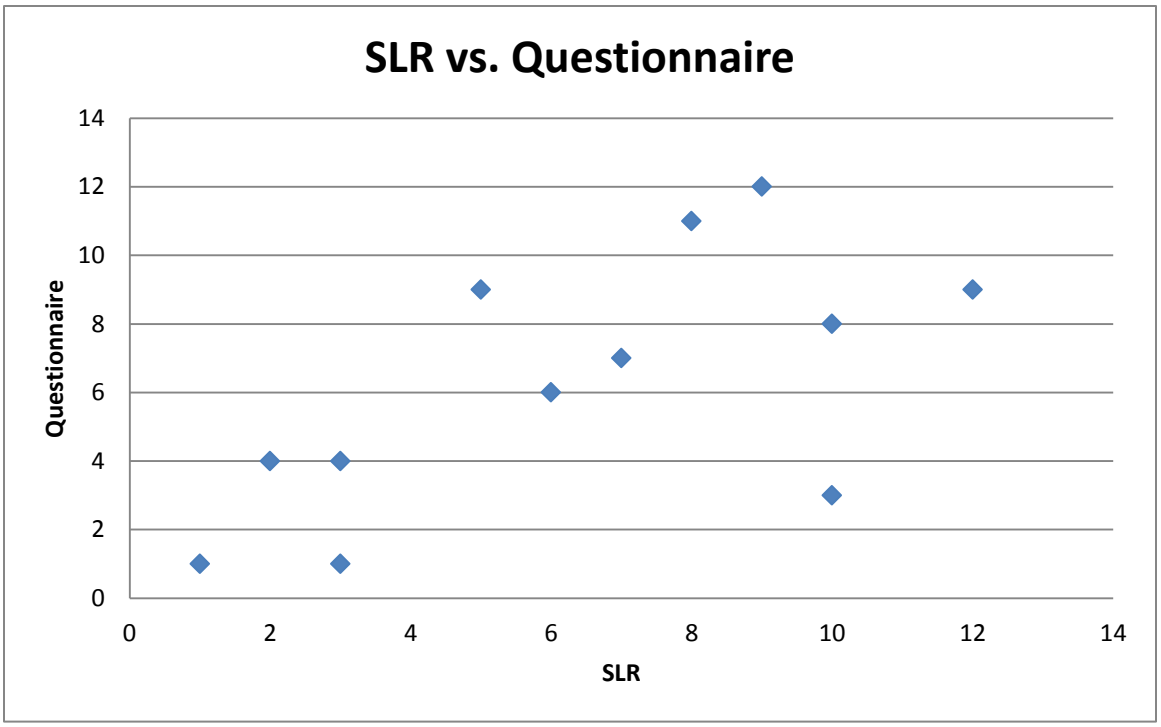

Figure 13 Scatter Plot of Spearman's Rank Correlation

CHAPTER 5

CONCLUSION

Reaching the end of our research journey, the conclusion chapter is the right place to provide a holistic view on our research in general, validity, contribution, limitations and future work. The results show that a high correlation between the literature and the industry. In the literature the top four challenges are: 'Miscommunication', 'Organization structure and policy', 'Knowledge management' and, 'Multiple communication channels' respectively. Whereas, the top four challenges in the industry survey are: 'Miscommunication', 'Knowledge management', 'Security' and, 'Organization structure and policy' correspondingly. There is an overlapping in three out of the top four challenges identified which gives us the implication of the alignment between the literature and the software industry.

Our research is focusing on two promising areas of research: GSD and social computing. Despite GSD adoption by large firms and organizations in the world, a plenty of critical issues are still unsolved. On top of these issues are miscommunication among different parties due to the differences in language, time and culture. Similarly, social computing has proven itself as a fascinating tool for informal communication. However, their adoption by GSD organizations is at slow pace and it's not as expected. Thus, our aim is to investigate the challenges that hinder GSD organizations of adopting social computing as a communication medium.

Two research methodologies were used in this thesis: SLR and survey. SLR is intended to provide a comprehensive scanning of all the articles targeting the challenges of adopting social computing in GSD environment. Its main purpose is to provide a list of all major challenges as found by researchers and academicians. The results shows that all the challenges cited in the literature can be classified into 12 main categories. Further, these categories have been correlated with the study type and the author country to reveal any hidden pattern. In addition, these categories have been distributed to experts who put their opinions on a five scale as follows: Strongly Agree, Agree, Disagree, Strongly Disagree, Not sure. The industrial experts opinions' and the literature results has been correlated using Spearman Rank correlation in order to determine the similarities and differences between industry and academic views. The result shows that 'Miscommunication' is the top fear of adopting social computing in the literature and in the software industry.

5.1 Contribution

Few research articles are discussing the challenges of adopting social computing in GSD settings. These articles are produced recently in the last few years looking at the issue from various perspectives. However, to our knowledge, there is no single study attempts to collect, classify and discuss the various challenges faced by GSD organizations in realizing social computing tools. Our work is of high value and it will serve as a reference for GSD academicians and practitioners to understand the various challenges that stop GSD organizations from adopting social computing.

Our research can be considered as the first stone that aid GSD experts in understanding the various challenges of adopting social computing and propose

appropriate solutions addressing them. The future work section will address this idea further.

5.2 Validity

The results of this research are based on a systematic literature review and a distributed online survey. Despite our extremely care to provide an accurate and valid data as much as we can, few points must be considered when adopting our results.

The correlation shows a strong correlation coefficient between SLR and the questionnaire and it supports our conclusion. But the threat to validity stems from the fact we don't cover all articles and we don't obtain responses from all GSD developers.

5.3 Limitations

A considerable effort has been done by the author to ensure the success of this thesis. However, there are some limitations and difficulties affect slightly the outcome of this research. GSD is not a popular concept in Saudi Arabia and as such, it was difficult to find the right experts who can put their inputs to our survey. In addition, there were some restrictions and difficulties in using various settings of the search engine of premier research indexes. Moreover, the lack of a standard universal definition of social computing makes it difficult for us to discriminate between various tools. Instant messaging for instance is classified as a social computing tool in some articles while it was not considered as social computing nowadays due to its basic operation. A major challenge in conducting our study was extracting the challenges from respected materials. Again, this field is emerging and very few articles are available addressing challenges clearly. In that regard, it takes a considerable effort to read the paper more than one and extracted the challenges.

5.4 Lessons Learned

This thesis is a result of a full year of work and effort. The experience is indispensable and the obtained knowledge is of great value. Conducting a systematic literature review is a very demanding task. It requires reading an enormous number of papers quickly, determining the right ones and evaluating the quality based on some criteria. I've learnt how to use the advanced setting of various academic databases' search engines. I've also learnt how to alternate between synonyms of terms to retrieve relevant materials. Synthesizing the results and correlate it with study type and author country strengthens my skills as a researcher. I'm able to see issues from various perspectives and connect them together in order to detect any hidden pattern. In addition, I have enjoyed inviting experts to participate in my survey. Their inputs, comments and responses have helped me a lot in understanding issue from practical side.

5.5 Future Work:

Our work is stemmed from the fact that there are few articles discussing the challenges that restrains GSD organizations from adopting social computing in their environment. The next step is to determine the severance of each challenge by classifying them into appropriate categories. In addition, challenges can be investigated individually and a set of solutions addressing a particular challenge can be proposed. It would be interesting if a model or a framework can be built relating the challenges with the causes of these challenges and the hypothesistical solutions all together.

Appendix

Challenges Details

No.	Challenge
1.	**Miscommunication** • Coordination among the distributed teams is a challenge due to time, geographical and cultural differences. • Cultural diversity may lead to different attitudes. • Misinterpret the intent and tone of an email or IM message and this lead to conflict in the group. • In case of using IM you have to share working hours with your team. • Different languages lead to misunderstanding. • Distance exacerbates the importance of human-centered aspects related to collaboration in distributed development. • Distributed teams lose awareness of social interactions and other members' activities. • Disrupted turn adjacency, which occurs when responses aren't received immediately after the message to which they refer, but are interrupted by messages on other topics or from other participants (caused by the system posting messages in the order in which they are received rather than as responses to particular questions) can lead to significant overlap between speakers, "dense and complex" exchanges, confusion and loss of coherence. • Misinterpretation and misunderstanding is an issue due to the lack of social interaction. • Divergence of concepts on meaning. • Convergence of concepts but divergence in meaning. • Lack of informal communication, resulting in low levels of trust and awareness of work and progress at remote sites. • Lack of common understanding of goals and requirements assigned to the team. This makes team members feel isolated and they are reluctant to collaborate, share and work together. • Different culture and conventions associated with the software development process.
2.	**Organization structure and policy** • Organization structure and dependencies between the work of core members and of their peripheral colleagues, and vice versa. • Cluster structure coordination, where to find important information when it is needed. • Emergent of new team members during the development process. • Lack of representing the organizational structure (status, profile and reporting relations of employees). • Different communication policies among different sites. • Making the use of social software mandatory for teams may take away from developers the fun of using such tools, a factor that usually fosters their adoption in general purpose scenarios. • Contact people policy especially while they are in meetings, and should one expect answers from those people. • Balance between getting the work done and responding to the mangers communication requests. • Establish a clear organizational structure with communicating responsibilities across sites. • Lack of guidelines and policy of usage. • Staffing and inadequate structure. • Emergence of location-spanning work practices. • Strict rules on who can use the social tools. • Ineffective management of shared knowledge among different team members causes duplication,

	inconsistency and lack of knowledge of project assets. • Group structural awareness.
3.	**Knowledge management** • Aspect of awareness, or in other words, to know who knows what, who works in which part of the project and who is who in the remote teams. • Lack of access to organizational resources including time, personnel, and project information. • For developers to reuse past solutions, a repository must capture and store documents in editable formats. • Contribute to the repository is challenging. • Brief comments in the repositories for code and documents don't have enough details. • Social computing tools not very suitable to the professionals in terms of content management. • Status of information might not be up to date; status information might be wrongly set or interpreted. • Version control and user access management. • A New technology requires a change in human interaction. • Lack of clear requirements issue.
4.	**Multiple communication channels** • Incoming messages can be distracting and provide harmful interruptions. • IM use during meetings might lead to poor concentration, multitasking might be difficult when doing complex tasks. • Parallelism communication channels. • Managing several opened windows and switching between them can be cumbersome especially if there is a large number of incoming invitations. • Multi-tasking, especially communicating and programming simultaneously. • Frequent interaction across sites. • Multiplicity implied the availability of many communication technologies for interaction. • Much of the developers' effort is wasted in switching back and forth between different applications to communicate and work together.
5.	**Limitations of social computing tools** • Lack of project status. • Transcript of the conversation. • Different communication modes for different communication needs. • Searching function is limited. • Symbol variety, Reprocessability, Rehearsability. • Appearance of the information need to be improved. • Delays of communication media. • Bandwidth of some technologies is limited. • Offering interoperability between tools and the lack of integration among tools.
6.	**Trust and privacy** • Trust as an influential factor on the member's cooperation performance. • Shared social identity. • Privacy mechanisms. • Trust in information provided through these technologies and the information provided through these technologies may lack focus and are often not of use to the participant. • Maintain a continuous presence in the tool, and use it for all aspects of collaborative development. • Concerns about information privacy have also become a concern in public social media.

	• Identity management and the issue of having many profiles. • Personal attributes. • Hesitation to use owing to privacy issues.
7.	**Social computing tool availability** • Social computing tool availability; while they are supported by some organizations, they are not available to some or all team members. • The importance of using the same tool and work not only with the same development environment when developing software in a distributed way, but also developing common social protocols through what sociology calls articulation work and meta-work. • Virtual teams combine different channels according to their communication needs. • The selection for primary communication tools for the project. • Lack of efficient social computing tool. • Selecting the appropriate social computing tools. Cost and effort of use as a factor in selecting tools (cost and technical learning curve) • Lack of knowledge on tool selection criteria.
8.	**Lack of motivation to use social computing** • Communication is costly and often considered as "overhead" to be minimized. • No or little perceived on return on investment. • Lack of "critical mass". • No reward for participation. • Link between contribution and productivity is not clear. • Misuse of tools reported. • Difficulty in studying the usefulness of a tool in a GSD domain. • Increased the workload. • Sustain the interest of participants to contribute over time.
9.	**Immediacy of feedback** • The bigger the team, the more people needed to keep in the loop. • Expectations of immediate response are not always met, because of e.g. meetings. • Expecting to answer a request within a certain time frame. • Transaction delays in comparison with face to face interactions and encounters. • Lack of simultaneous feedback (messages were sent after they were typed rather than while they were being typed, causing a lag). • Latency in information exchange
10.	**Alignment with the developers' practices** • Technologies are not aligned with their current everyday work practices. • The purpose and the design of using the social network are different for professionals comparing with normal users. • Not appropriate for cross-cutting concerns among developers. • Creating new requirements needs to be as easy as possible. • Lack of software maintenance appropriate social computing tools. • Some tools are so specific.
11.	**Security** • Data security. • Information safety, security and compliance to regulation are important factors in enterprise contexts that distinguish enterprise social networks from their public counterparts. • Data protection. • Access to information might not be granted to partner organizations. •

12.	**Social computing tool familiarity** • Setup and familiarization is time-consuming. • Participants need help to be familiar with the tool. • Lack of comfort or familiarity with remote teamwork for some team members at first (social learning curve). • Lack of knowledge on tool selection usage

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