Global Software Development Geographical Distance Communication Challenges

Areej Al-Zaidi and Rizwan Qureshi
Faculty of Computing and Information Technology, King Abdulaziz University, Saudi Arabia

Abstract: *Global Software Development (GSD) is a major direction in software engineering. There is interest in applying scrum practices in distributed projects. Project stakeholder distribution in GSD is represented by geographical distance, which generates challenges for communication. This paper is written to evaluate the effect of scrum practices in mitigating geographical distance-based communication challenges. We also suggest some mitigation strategies those are supported by our survey respondents. This study finds that scrum provides advantage in mitigating geographical distance-based GSD communication challenges. This research is a reference guide for other researchers to validate and extend current knowledge about Scrum practices i.e., how it can be used to mitigate geographical distance-based communication challenges in GSD.*

Keywords: *GSD, communication challenges, scrum, geographical distance-based, mitigation strategies, survey*.

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1. Introduction

In the recent years, software development environment is shifting from centralized to a distributed environment in order to offer benefits over the conventional techniques. Global Software Development (GSD) is software development that is separated through two or more sites that are dispersed by national or continental lines. GSD can offer benefits such as improving time to market, improve quality, round-the-clock development, access to cheaper skilled resources, reach to local knowledge and growing productivity.

However, along with benefits, GSD suffers from challenges relating to communication of the software development process. GSD typically involves stakeholders located in distributed geographic sites such as geographical distances can result in communication challenges that need to be eliminated.

Design of agile methods typically allows close interaction between development team members as a collocated development teams. In fact, face-to-face conversation is the most efficient way of exchanging information in a development team which considered a problem in GSD. Scrum methodology is the most popular approach agile software development which is an incremental methodology that characterized by reliability, responsiveness and flexibility. Among the various agile methods, Scrum focuses on project management, are the most well-known due to its flexible approach, and it's based on the collocated, frequent and close collaboration.

Increased number of sites and number of project members, also lack of tool support, and all these factors of GSD may impact on communication and collaboration of project and restricts the use of scrum practices. Therefore, GSD needs to identify mechanisms to mitigate these challenges. Strategy is any activity performed to mitigate the effect of problems associated with challenges. In this paper sets some of the mitigation strategies for challenges .

Scrum practices are increasingly being adapted in GSD to get the advantages of both approaches. The study focused on examining scrum practices provide a contribution to mitigate GSD geographical distance-based communication challenges. Geographic distance's communication challenges in GSD and Scrum practices formed the axes of a research framework via suggesting some mitigation mechanisms.

The paper is organized as follows. Briefly overviews related fields in section 2. Section 3 describes problem statement. Section 4 depicts the details of proposed solution. Section 5 presents validate of the proposed solution. Concludes and addresses future work in section 6.

2. Related Work

According to Ramanujam and Lee [14], "Scrum software development had attracted a great deal of attention in recent years due to its flexibility, responsiveness and reliability." And they proposed a collaborative agile scrum software development framework for complex multi-vendor competing environments. In the building of large systems it is imperative that organizations engage multiple vendors so that they can bring each of their specializations into the project.

Research has shown that the use of scrum within a company can lead to significant benefits, and that its use is not limited to local projects. Also functioning team of product managers should cooperatively with

the development team to handle large amounts of complex requirements in an agile environment [20].

In [1], it is identified that Requirements Understanding (RU) is a severe challenge for software companies of Kingdom of Saudi Arabia that are involved in GSD. The main challenges faced in GSD are communication problem, culture diversity, coordination, geographical distance, time zone difference but the culture and loss of communication are the most challenging issues faced during RU, document management and competence management can be used to overcome RU challenges in a global context.

One of the main challenges of GSD practices is to ensure effective communication among the team members [17]. Shah *et al.* [17] identified the solution by using ontology's as communication facilitators, modularization of work, study of the cognitive nature of people and the characteristics of their environment and training on cultural norms. Also finds agile development techniques are best suited for GSD environment.

Sriram and Mathew [18] describe the following in support of the use agile methodologies in GSD: "Although the principles of agile methodology like scrum and the principles of global software development are apparently contradictory in many areas." Some studies reported that scrum is the widely used methodology in GSD. Some studies have focused on the potential use of a scrum in GSD; however, concrete evidence is not provided on the implementation of varied type of scrum in distributed project scenario for large projects.

Hossain *et al.* [7] categorized the key risks of GSD project contextual factors, and current strategies to deal with these risks while using scrum practices with reference to the seven of risks. This categorize have some limitations: the conceptual framework is based on twenty papers identified through a Systematic Literature Review (SLR) that addressed the use of scrum in GSD projects. One of the main limitations of this framework is that it has a small and narrow project specific focus. It is very difficult to identify all the risks and the corresponding strategies to reduce these risks when using scrum in a GSD product consisting of several projects.

In 2011, running an GSD project, students distributed across three countries developed mobile solutions targeting the theme of sustainability. They followed the Scrum process and used the IBM Rational Team Concert (RTC) tool. The teams faced many difficulties such as: readings are not enough to understand Scrum before the project, difficulties to dissociate the roles of developer and product owner, scrum master, no preparation of the retrospective, sprint planning done late, and the burn down chart is not used as an instrument to monitor the progress of the team [16].

Scharff [15] described a GSD model where extended teams of students distributed across two to three countries and developers used Scrum to develop mobile applications for different mobile platforms. It was a first attempt to introduce auditors to provide additional support in fostering a process appreciation and adherence to scrum and their work was better supported by end-to-end tooling infrastructures such as RTC while developers were satisfied because they found their experience in the project rewarding and challenging.

Su [19] describes some management lessons learned from a GSD project undertaken in an educational setting with the students and this It was the first time that the project adopted agile methodologies and scrum for the development of an educational mobile application. It is concluded with some important management principles such as: Students should be motivated, concentrated on the tasks that matters most, work at a constant pace and good understanding of strength and weakness of each team member in order to cover the shortcomings of the weak members.

According to Gomes and Marczak [6], "The challenges imposed by geographical, temporal, and cultural distance are numerous." The software engineering community has been studying these challenges but few studies are discussing the solutions of GSD projects [6].

In [12], a systematic review on GSD is performed using a survey to gather information about the key challenges and mitigation strategies in GSD. The main categories are communication, coordination, and control and each category has subbed categories of geographical distance, temporal distance, and socio-culture distance. From the systematic review, they collected 48 challenges and 42 mitigation strategies also they identified by survey respondents with four additional strategies that were found from the survey. Therefore, it was concluded that all the challenges and strategies that were collected during the SLR were prevalent in certain industrial settings.

In [11], it is found that a transition from Rational Unified Process (RUP) to scrum brings a positive effect in requirement's engineering, communication, cost management and cross-functionality of the distributed teams. In this way, agile practices can have a positive impact on GSD projects and can help to mitigate many of the well-known challenges of GSD.

Project stakeholder distribution in GSD is characterized by temporal, geographical and socio-cultural distance, which creates challenges for communication, coordination and control. Practitioners constantly seek strategies, practices and tools to counter the challenges of GSD. Overall, the literature appears to suggest that scrum practices have no distinctive advantage over other development methods in mitigating temporal distance-based

challenges [8]. The proposal has some limitations. First, the framework is a theoretical contribution that remains to be empirically validated. Second, it may be possible, in some instances, that the researchers misinterpreted an author's intent. Third, the challenges and mechanisms contained in the framework are not exhaustive so may not be complete. Finally, the framework implicitly assumes a generic GSD context so it may obscure project-specific variations in mechanisms.

In [2], it is examined where scrum practices are used in four GSD projects. There is no distinctive advantageprovided in mitigating coordination challenges. Four temporal, geographical and socio cultural distance-based coordination challenges were identified from the literature along with seven scrum practices. Consequently, based on the cases studied, it was found that scrum offers a distinctive advantage in mitigating geographical and socio-cultural but not temporal distance-based GSD coordination challenges.

The limitations of this result are: First, only four of the twelve GSD challenges identified from the literature were examined. Second, the study focused on the Scrum practices, rather than the tools and mechanisms that mediate the challenge mitigation. Third, the study did not directly compare scrum practices with traditional development methods. Khan *et al.* [9] proposed a framework to address the communication risks that are one of the obstacles in GSD projects. According to Khan *et al.* [9], communication risks are difficult to address during the Requirement Change Management (RCM) process. A framework is proposed to categorize risks into geographical, socio-cultural and temporal distances and it is also used to mitigate the communication risks [9].

Five communication wastes are identified and a solution is proposed to mitigate them in globally distributed agile development [10]. These wastes are lack of involvement, lack of shared understanding, outdated information, restricted access to information and scattered information. A case study is conducted to validate the proposed solution [10].

Qureshi and Sayid [13] proposed a web system to mitigate communication and coordination challenges in GSD projects using Scrum methodology. The proposed system offers seamless communication, collaboration and knowledge sharing among the distributed teams in GSD [13]. Geographical systems and its associated challenges related to site selection are illustrated [3, 4, 5].

Table 1 shows a brief description of the literature reviewed regarding this paper including project title and the problem found in them.

3. Problem Statement

Examining whether scrum practices, used in global software development projects provided any advantage in mitigating geographical distance communication challenges.

Table 1. Comparison of the related work.

Problems Found	Paper Title with reference number
Use scrum practices in four distributed GSD projects to leverage the benefits of Agile methods over traditional software engineering methods, provided any distinctive advantage in mitigating coordination challenges . In this paper limitations - Only four of the twelve GSD challenges were examined. - The study did not directly compare Scrum practices with traditional development methods.	Scrum Practice Mitigation of GSD coordination challenges: A distinctive advantage?[2]
SLR and illustrate of the key risks of GSD and current strategies to deal with these risks while using Scrum practices. - based on twenty papers identified through a SLR. - Specific small and narrow project. - Difficult to identify all the risks and the corresponding strategies when consisting of several projects. With these risks while using Scrum practices.	Risk identification and mitigation Processes for Using Scrum in GSD: A conceptual framework [7]
Limitations in that paper are theoretical framework, may be possible the researchers misinterpreted and the challenges also mechanisms contained in the framework are not exhaustive.	Scrum practices in GSD: A research framework[8]
Limitations in that paper - All the challenges and strategies collected in industrial settings. - Number of respondents could be a factor in the results. - No correlation analysis between challenges and risks, or between challenges and strategies.	Risk identification and risk mitigation Instruments for GSD: Systematic review and survey results [12].
Running GSD project, difficulties encountered by the students distributed across three countries developed mobile solutions targeting the theme of sustainability. They followed the Scrum process and used the IBM Rational Team Concert tool.	On the difficulties for students to adhere to scrum on GSD Projects: Preliminary results [16].
Described GSD model where extended teams of students distributed across two to three countries and developers used Scrum and Agile to develop mobile applications for different mobile platforms.	Guiding GSD projects using scrum and Agile with Quality Assurance [15].
One of the main challenges of GSD practices is to ensure effective communication among the team members - Still there caveats are affixed with the solutions, - Modularization of work.	Communication issues in GSD [17].

4. The Proposed Solution

Agile methods allow face-to-face communication and it is very efficient to share information among collocated team members but it is a big problem in GSD projects. Geographical distance is a measure of the effort required for travelling between sites and it is very necessary for the relationships (team spirit) between the distributed teams.

Due to dispersion of sites and development teams located in different countries, limited face-to-face meetings can reduce possibility of informal contact which reduce team awareness and causes negatively trust lack of team cohesiveness, interaction and impact general management. We need suitable mechanisms to mitigate geographical distance-based communication challenges to get the benefits of scrum in GSD.

4.1. Tools Used

4.1.1. Multiple Communication Modes

Scrum team during their meetings can be selected the appropriate communication tool depend on the communication bandwidth.

- Synchronous communication tool sallow people to use the "same time, different place" mode, so, it enables real-time communication. Drawbacks of synchronous tools are cost and high communication bandwidth and require same-time participation. The most common synchronous tools are: audio conferencing, web conferencing, video conferencing, chat, instant messaging, telephone, net meeting, and shared mailing list.
- Asynchronous communication tools allow people to use the "different time-different place" communication model to keep on communicating over a period of time. The most common asynchronous tools are: Discussion boards, wiki, web logs (blogs), messaging (e-mail), streaming audio, streaming video, desktop and application sharing.

4.1.2. Version One's Project Management Tool

Version one is project management software designed from the bottom up to support agile development methodologies such as scrum. It is used by teams to easily plan and manage Scrum projects. Version one tool allows to:

1. Manage backlog items, tasks, and bugs;
2. Plan sprints and track them;
3. Streamline sprint reviews;
4. Generates burn down charts;
5. Conduct retrospectives;
6. Provide electronic taskboards and storyboards;
7. Prioritize product backlog and monitor scrum team impediments.

4.2. The Proposed Framework

First, stakeholders of Scrum teams are grouped in a one location and perform first sprints as a combined team before they distributed. Second, for distributed teams, must agree on common definition for scrum terminologies, concepts, responsibilities and roles.

In each site, forming autonomous local scrum team that performs their own scrum with own local scrum master and to each team assign independent architectural subsystems to reduce communication and dependency between sites. For each sub-team, Scrum meeting will be held daily with own local scrum master to discuss about what they did, and what they are planned to do also discuss about obstacles in way or slowing team down. Make asynchronous retrospective meetings by publishing the results of minutes of a local Scrum meeting on wikis or blogs and other teams can post their comments there. As shown in Figure 1. The proposed framework is shown in Figure 2.

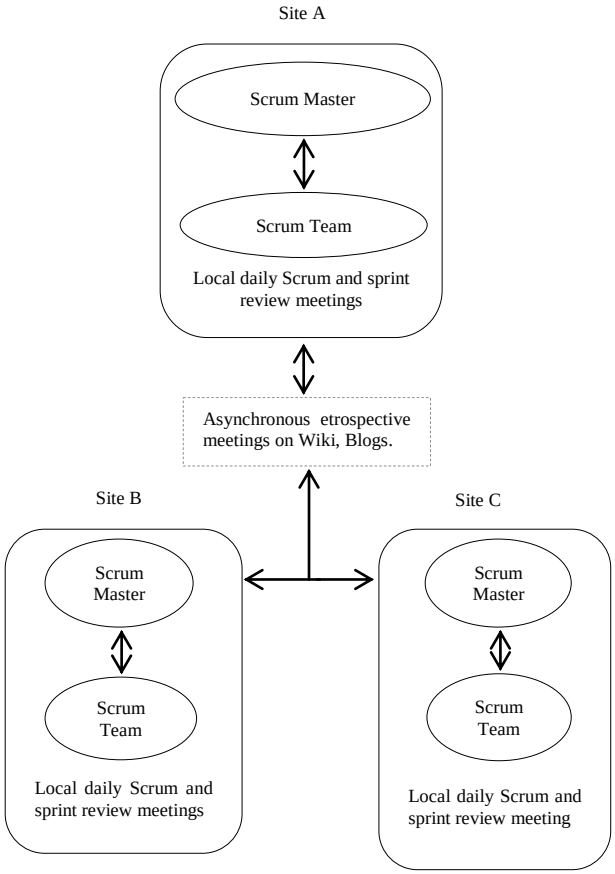

Figure 1. Autonomous local scrum team structure.

The practices scrum of scrums occurs once in a week between key members or representative (Scrum master from each sub-team) to coordinate between them and discuss about product backlog and any new requirements from the client also asked about work for each team since last met, what do before meet again, anything slowing team down and asked if any team want to put something in another team's. During themeetings, to provide a rich communication environment also to prevent unreliable transmission, meetings, to provide a rich communication environment also to prevent unreliable transmission, using practice like multiple communication modes such as web camera, video conference, live meeting, IRC, teleconference, audio/video Skype.

The scrum team must have web-based scrum project management software to increase transparency and visibility of project and to support the scrum practice, therefore, scrum teams are using 'Version One' to easily access to the electronic planning and manage backlog and display burn down charts. All of the distributed scrum team members need to be present and share in every scrum meeting practice. During scrum of scrums, scrum master teams will talk and control the scrum project management software 'Version One' while rest members in other different sites listening to the audio and look at the same screen

by sharing and viewing desktop of the presenter remotely and the same principle will apply when it's time for a remote member to present.

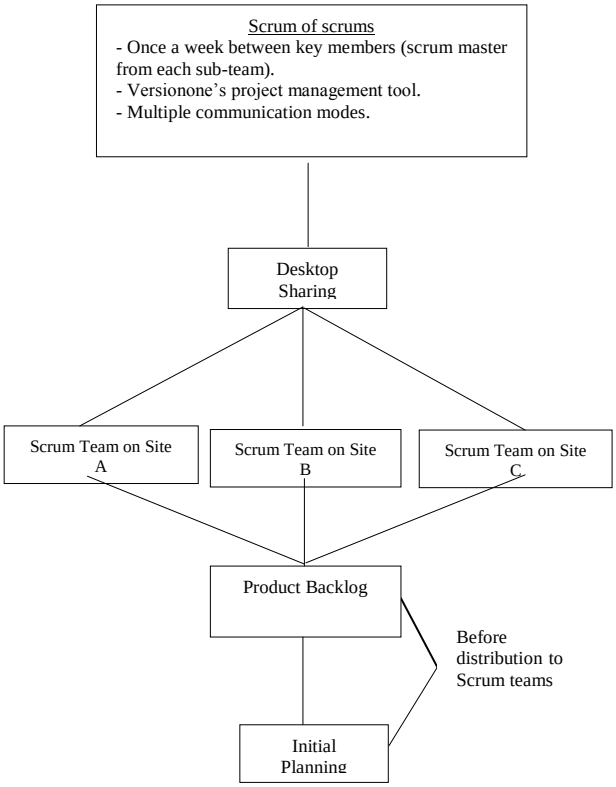

Figure 2. The proposed framework.

For increased collaboration, along with formal meetings are also allowed additional distributed meetings for clarifying issues for example between architects of each sub-team.

5. Validation of the Proposed Solution

Validation of the proposed solution is one of the most important points that need to any research. In this paper the validation of the proposed solution through used an electronic survey. The purpose of using this method it's not too much time consuming and gives the respondent much of time to think and answer questions be credible.

Validation of the proposed solution will be through collecting a sample of people who answer an electronic survey that composed of 19 questions. An electronic survey will be target distributed to specialists in software engineering through social sites such as Twitter and Facebook and Email. Likert scale will be used in this research to answer questionnaire. Likert scale is given in the following Table 2.

Table 2. Likert scale.

Strongly disagree	1
Disagree	2
Neutral	3
Agree	4
Strongly agree	5

Questions divided into 3 goals were arranged according to their relevancy to defined goals this goal:

- Geographical distance communication challenges can be faced in global software development projects.
- The benefits of using some scrum practices on geographical communication GSD challenges.
- The effectiveness of the proposed solution to mitigate of geographical distance communication challenges.

A statistical analysis is made on the basis of gathering data through the distribution of questionnaires. The analytic form is represented through frequency tables and charts showing the exact degree of analysis. Describe the validation results on the basis of results below.

5.1. Cumulative Statistical Analysis of Goal 1

Geographical distance communication challenges can be faced in global software development projects.

Distribute project stakeholder in GSD through geographical distance which creates challenges for communication because developers are being located indifferent countries that cause difficult to hold face-to-face meetings. The result of the analysis of the goal 1 is shown in the Table 3.

Table 3. Frequency table of cumulative goal 1.

Q. No.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	0.00	0.00	17.5	52.5	30
2	0.00	0.00	25	55	20
3	0.00	0.00	22.2	62.5	15
4	0.00	0.00	7.5	65	27.5
5	0.00	0.00	12.5	65	22.5
Total	0.00	0.00	84.7	300	115
Avg.	0.00	0.00	16.95	60.04	23.01

As it is cleared from the cumulative descriptive analysis of goal 1 that 60.04% of the sample agreed that geographical distance communication challenges can face in global software development projects and 23.01% strongly agreed to it while 16.95% remained neutral as shown below in Figure 3.

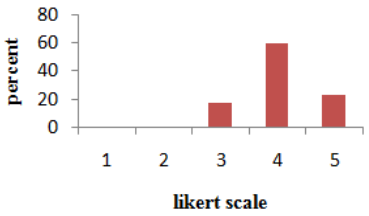

Figure 3. Graphical representation of goal 1.

5.2. Cumulative Statistical Analysis of Goal 2

The benefits of using some scrum practices on geographical communication GSD challenges.

This paper uses some of scrum practices whether inherent or non-inherent to examine whether scrum practices improve communication, develop trust, offer

visualization, increase quality and teamness in GSD by using sprint planning, scrum of scrums, retrospective meetings, daily scrum meetings, local scrum, synchronous and asynchronous communication. The result of the analysis of the goal 2 is shown in Table 4.

Table 4. Frequency table of cumulative goal 2.

Q. No.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
6	15	40	10	25	10
7	0.00	2.5	12.5	67.5	17.5
8	0.00	7.5	10	65	17.5
9	0.00	5	10	70	15
10	0.00	2.5	15	62.5	20
11	0.00	2.5	15	57.5	25
12	0.00	2.5	12.5	75	10
13	0.00	0.00	17.5	67.5	15
Total	15	62.5	102.5	490	130
Avg.	1.88	7.81	12.81	61.25	16.25

As it is cleared from the cumulative descriptive analysis of goal 2 that 61.25% of the sample agreed that scrum practices could be useful in geographical communication GSD challenges. And 16.25 % strongly agreed to it 7.81% disagreed to it and 1.88% strongly disagreed to it while 12.81% remained neutral as shown in Figure 4.

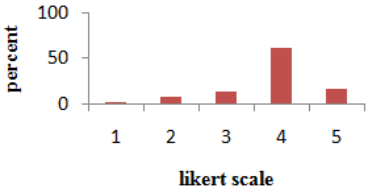

Figure 4. Graphical representation of goal 2.

Table 5. Frequency table of cumulative goal 3.

Q. No.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
14	0.00	0.00	17.5	50	32.5
15	0.00	2.5	15	67.5	15
16	0.00	5	12.5	65	17.5
17	0.00	0.00	7.5	77.5	15
18	0.00	0.00	7.5	75	17.5
19	0.00	0.00	12.5	57.5	30
Total	0.00	7.5	72.5	392.5	127.5
Avg.	0.00	1.25	12.08	65.42	21.25

5.3. Cumulative Statistical Analysis of Goal 3

The effectiveness of the proposed solution to mitigate of geographical distance communication challenges.

This goal measures the effectiveness and efficiency of proposed solution, which consists of the integration of scrum practices inherent and non-inherent with each other and with the modification in some of them in order to mitigate of geographical distance communication challenges in GSD. The result of the analysis of the goal 3 is shown in Table 5.

As it is cleared from the cumulative descriptive analysis of goal 3 that 65.42% of the sample agreed that effectiveness and efficiency of proposed solution to mitigate of geographical distance communication challenges in GSD. And 21.25% strongly agreed to it 1.25% disagreed to it while 12.08% remained neutral as shown in Figure 5.

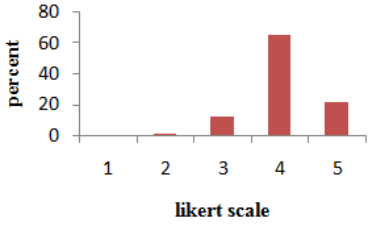

Figure 5.Graphical representation of goal 3.

5.4. Cumulative Evaluation of 3 Goals

The evaluation of 3 goals shows that 0.63% are strongly disagreed, 3.02% are disagree,13.95% are neither agreed nor disagree, 62.24% are agreed and 20.17% are strongly agreed as shown in Table 6 and Figure 6.

Table 6.Frequency table of cumulative 3 goals.

GoalNo.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	0.00	0.00	16.95	60.04	23.01
2	1.88	7.81	12.81	61.25	16.25
3	0.00	1.25	12.08	65.42	21.25
Total	1.88	9.06	41.84	186.71	60.51
Avg.	0.63	3.02	13.95	62.24	20.17

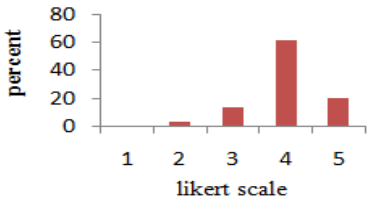

Figure 6. Graphical representation of cumulative 3 goals.

6. Conclusions and Future Work

This paper focused to show the advantages of scrum method in GSD projects. It also aimed to study that how much Scrum practices helped to overcome GSD communication challenges. In fact; this study focused on tools and mechanisms of scrum to mitigate GSD challenges. In this paper, we study one of the factors that create a restriction in communication due to geographical distances among teams and limited face-to-face meetings. Limited face-to-face meetings reduce informal contact and this can lead to reduction of teamness, loss awareness of task and decreased trust. This challenge can be met by using proposed solution, which making the communication process are simpler and effective. We can conclude that, scrum practices have a positive effect on GSD projects and the properties inherent in scrum method can benefit distributed software development projects by helping to mitigate geographical distance-based communication challenges of GSD. The framework represents a theoretical contribution that needs to be tested and empirically validated. Future research will conduct case studies in an industrial context to

validate, modify and extend the framework as a reference.

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Areej Al-Zaidi is amaster student in the Department of Information Technology,Faculty of Computing and Information Technology, King Abdulaziz University, Saudi Arabia.

Rizwan Qureshi received his B.Sc. Engineering degree from Punjab University, Pakistan in 1997, M.Sc. IT degree from Staffordshire University, UK in 2002 and Ph.D. Computer Science degree from National College of Business Administration & Economics (NCBA&E), Pakistan in 2009. This author is the best researcher awardees from Faculty of Computing & Information Technology, King Abdulaziz University Saudi Arabia in 2013 and Department of Computer Science, COMSATS Institute of Information Technology Lahore Pakistan in 2008.