Requirements Understanding in Global Software Engineering: Industrial Surveys

Hashim Khan [1+], Arshad Ahmad [2], Conny Johansson[3] and Mohammed Abdullah Al Nuem [1]

[1, 4] King Saud University, Riyadh, Saudi Arabia

[2] University of Kaiserslautern, Kaiserslautern, Germany

[3]Blekinge Institute of Technology, Ronneby, Sweden

Abstract. Going offshore has become a norm in current software organizations due to several benefits like availability of competent people, cost, proximity to market and customers, time and so on. Despite the fact that Global Software Engineering (GSE) offers many benefits to software organizations but it has also created several challenges/issues for practitioners and researchers like culture, communication, co-ordination and collaboration, team building and so on. Further, Requirements Engineering (RE) itself is a very complicated and human intensive activity but GSE had made it more complicated and diverse. Therefore, people working in offshore environment face challenges in Requirements Understanding (RU). In this paper, we identified different GSE challenges and its impact on RU. Furthermore, several industrial surveys have been conducted with the intent to get real environment industrial perceptions and opinions regarding the identified challenges and its impact on RU.

Keywords: Requirements Understanding, Requirements Engineering, Global Software Engineering, Global Software Development

1. Introduction

With the advent of modern technologies the world has been changed to global village, therefore software industries have also started focusing from shifting traditional form of collocated development to offshore development. Besides, globalization of markets, technologies, economical factors, availability of resources and methodologies has certainly influenced software development by in large [1].

Global Software Engineering (GSE) has been adopted widespread and gaining fame with the passage of time. Besides, as in GSE development teams are dispersed geographically therefore its major advantage is closeness to market/customer. Further, GSE main driving force is economical factor i.e. as the product is developed in less time and resources used [1, 2]. Moreover, GSE offers many benefits like cost effectiveness, shorter development time, skilled people and less use of resources [3].

Despite the fact that GSE has offered many advantages, it has also created several problems and challenges for researchers and practitioners. As GSE teams are dispersed geographically so therefore several problems occurs like communication, culture issues, trust, co-ordination, Knowledge Management (KM), RE and so on [2].

RE phase is considered to be crucial and tricky phase in software development life cycle (SDLC) and especially becomes more challenging in GSE [4]. As in GSE, organizations are spread geographically so therefore communication and coordination becomes more difficult which also has impact on the requirements being gathered. Further, requirements' understanding is considered to be one of the biggest and

---

+ Corresponding author. Tel.: + 966-14698940; fax: +966-14674278.
  E-mail address: yahashim@gmail.com

challenging issues for academia and industries in Global Software Development (GSD) from last decade [4, 5]. In addition, RU problem can arise at any stage of RE like when requirements negotiation, communication, prioritization and specification takes place. For example in requirements negotiation the development teams might want to know what is the rationale behind including the new requirement or changing the requirement? Therefore development team working offshore might misunderstood requirements due to lack of communication, lack of co-ordination between offshore teams, different time zones and culture differences [6, 4].

The main purpose of this paper is to identify the challenges of RU in GSE or GSD. This aim has been achieved in several stages: At first, a thorough literature study was conducted with the intent to identify RU challenges in GSD from literature. Then secondly, several industrial surveys have been conducted to identify the challenges of RU from the real environment of industries working offshore. Finally, the identified challenges from academia and industry are compared and based on the impact level of those challenges results are generated.

2. Related Work

2.1. Requirements Engineering

Software development has been problematic since 1960s, which in turn leads to late, lower quality, unsatisfied customers and over budget delivery of the system. According to [9], one of the main reasons behind these problems is difficulties and misunderstanding of requirements.

As RE is the first activity/phase of SDLC, therefore, it has great importance throughout all phases of software development i.e. design, development, testing, and maintenance. According to [10], the process of RE should be defined in more detailed and organized way in order to get better quality software products. Furthermore, after completion of RE phase the output of this phase serves as input to the design phase, and then design phase serve as an input to the development and so on. If the initial input from the requirements to the design and so on is understandable, unambiguous and correct, then the resulting product will be of high quality and consistent with customer needs. On the other hand, if the initial input is ambiguous and has conflicts, then the output of SDLC will be over budgeted, late and low quality product. Hence, RE is the core and most important phase of SDLC.

According to [9, 10], despite the importance of RE process (phase), it has also brought problems (challenges) with itself which have destabilized the needs and expectations of organizations and stakeholders. Furthermore, different challenges have been identified in the literature faced during RE phase like inadequate requirements traceability, complexity of application and so on, for further details see [9, 10, 11]. According to [5, 9, 10], lack of *RU* is one of the biggest challenge which is due to the improper communication, organizational policies and political factors, culture diversity, KM and so on. Moreover, misunderstanding of requirements may arise due to conflicts, ambiguities, incorrect interpretations and incompleteness of requirements because different stakeholders have different views and perception about a specific problem.

2.2. GSE puts new Challenges on RU

As discussed earlier RE is the crucial and challenging phase of SDLC and GSE has brought new challenges like culture difference, geographical dispersion, time zone differences and so on which has made even more complicated the RE process [5, 12, 13, 14]. Likewise, RE activities are becoming more challenging in GSE due to lack of interaction among teams across boundaries [12]. Therefore, resolution of misunderstanding and conflicts of requirements become more difficult because it then requires effective communication, coordination among stakeholders to manage, negotiate and specify a specific requirement issue.

Different problems have been reported in RE activities due to GSE challenges. According to [13, 14], culture have different values and beliefs which lead requirements towards misinterpretation and miscommunication among teams. For example, developers having different cultures may interpret requirements differently according to their own values and beliefs. In addition, these culture values and beliefs present with requirements are very hard to understand and create problems in RU like misinterpretations, conflicts and ambiguities. Likewise, time zone may also impact requirements especially

requirements communication because the time available for synchronous communication is short in large time zones which may lead to delay and misunderstanding of requirements. Furthermore, inadequate-communication and coordination may also lead to conflicts, misunderstanding and misinterpretation of requirements, due to which different RE activities like negotiation, prioritization and analysis can be affected by in large [5, 14].

In GSE a lot of work has been done on RE where different challenges and solutions to these challenges have been identified and mentioned. But all of the research is specific to only one RE activity like requirements management [15, 16] and requirements specification [17], etc. However, the focus of this research study is RU because it is one of the most challenging issues considered in GSE for both researchers and practitioners [4, 5]. Therefore, the GSE challenges faced by industries identified from literature are considered as RU challenges in global context. Moreover, GSE challenges have greatly affected RU globally as shown in Figure 1.
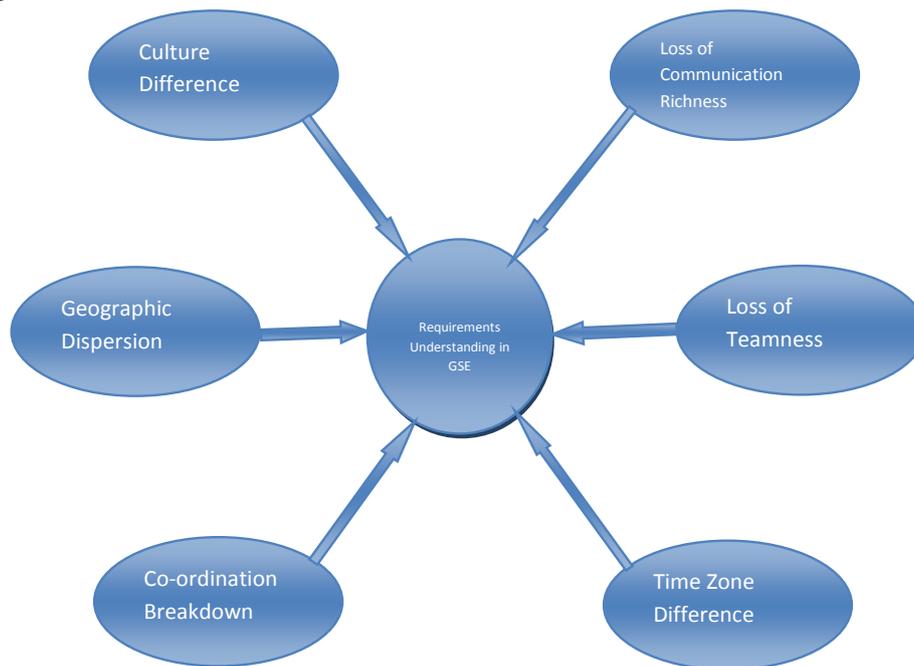

Fig. 1: GSE impacts on requirements understanding.

3. Research Methodology

The research question which motivated this study was "What are the challenges of RU in GSE?"

The research approach of this study was only qualitative; therefore, interviewing technique was used for conducting survey in software industries involved in GSD. For this research work semi-structured interviews were conducted because it helps and enables interviewers to ask questions according to the interest of discussion [7]. For this purpose open-ended questionnaire was designed for conduction of interviews.

For this research study three interviews were conducted in two software companies working in Telecom Sector namely Company A and Company B (Companies names are not mentioned due to confidentiality). Two interviews were conducted in Company A with two different persons and both of the interviewees were specifically working in field of RE. The first interviewee was person X working as a Technical Product Manager (TPM) in company A and has thirteen years' experience. Person X is directly involved in RE activities and his main responsibilities included initiating requirements, negotiating, involved in decision making, checking requirements fulfillment and requirements conflicts resolution. The second interviewee was person Y who also working as a TPM in Company A and has approximately eleven years of experience in Telecom companies. As Person Y was working in the same company as Person X with same position so therefore they have the same tasks and activities in RE. However, interviewee X and Y were from same company but working on different projects, therefore data gathered was very useful for this research study. Third interview was conducted with Person Z and was working as a Supplier Manager and has three years'

experience at Company B. Before this position Person Z was working as a Software Quality Engineer. Although, Person Z is not involved directly in RE activities but he is quite competent and has a blend flavor of experience of both academia and industry. Moreover, he has deeper insight and knowhow of RE activities carried out in his Company B.

The interviews sessions were allotted by the interviewees according to their own suitable and flexible dates and time. According to Fowler [8], interviewers should have flexible schedules so that interviewee (s) can make an appointment at any time suitable to them. In this research study all the interviews sessions were given by the interviewees which were quite flexible and comfortable for both concerned parties. The interviews sessions given by interviewee X and interviewee Z were 2 hours while interviewee Y given us 1 and half hour.

4. Interview Results

The main intent behind conducting industrial interviews were to get industrial perceptions and opinions regarding the challenges of RU in GSE and to know the severity level of those challenges identified in industries. In addition, the result of interviews conducted in both companies does not differ so much from each other except the severity levels of each identified challenge. Besides, the difference in severity levels of each challenge is due to size of organization, culture of organization, setup of organization and number of projects and its complexities. Moreover, as shown in Table I; depicts the severity level of each identified challenge of RU due to GSD in both Company A and Company B.

Table 1: Challenges of RU in GSE (Company A and Company B)

Challenges	Company A	Company B
Culture Differences	🔴	🔴
Geographic Dispersion	🔴	🔴
Loss of Communication Richness	🔴	🔴
Co-ordination Breakdown	🔴	⚫
Loss of Teamness	⚫	⚫
Time Zone Difference	🔴	⚫

🔴 → DEPICTS MAJOR ISSUE   ⚫ → DEPICTS MINOR ISSUE

From literature review the authors have identified several challenges of RU in GSE. Further, in order to get a better understanding and insight of these issues and challenges, views of Company A and Company B are summarized in Table II.

Table 2: Views of company A & B on identified gse challenges from literature.

Sr. No	Ref. No	Challenges Identified from Literature Review	Views of Company A & Company B
1.	[2, 18, 19]	**Culture Differences:** Different ways of thinking, solving problems, attitudes, commitment, language and style of communication and so on.	Culture is not the way of celebrating Christmas but rather it's a way of thinking and solving problems. It's hard to reach on consensus due to lack of understanding and commitment.
2.	[19, 20, 21, 22]	**Geographic Dispersion:** Geographic dispersion is like "out of sight out of mind" which has caused several problems like trust, motivation, less co-ordination, miscommunication and control.	Misunderstanding of organizational framework, misunderstanding requirements and increases rework.
3.	[22, 23, 24]	**Loss of Communication Richness:** As distance increases communication becomes more problematic and challenging, availability of technology infrastructure, lack of closer interaction, mode of communication and lack of face-to-face interaction.	Lack of face-to-face meetings, availability and use of appropriate media, less co-ordination, less informal communication and culture differences.
4.	[21, 19]	**Co-ordination Breakdown:** It's hard to meet personally everyone i.e. lack of interaction and lack of intense communication.	Lack of close collaboration, different units dispersed far from each other, lack of frequent visiting.

5.	[19, 25]	**Loss of Teamness:** Lack of face-to-face meetings and hence trust is lost, culture diversity, difference in organizational standards, policies and development processes and language barriers.	Trust is the major issue, motivation, awareness, culture differences and lack of frequent communication.
6.	[21, 23, 26]	**Time Zone Difference:** As distance increases time zone difference increases which in turn causes many problems like arranging meetings, loss of intense interaction and co-ordination and mode of communication.	Discussing urgent issues and problems when needed, delay in response and increases rework due to unresolved issues on time. Further, team work is necessary to negotiate issues between different units at the same time.

5. Discussion

5.1. Culture Difference

By analyzing all of the interviews in both companies have enabled the authors to know the opinions on culture differences in industries. The interviewee X at company A claimed as "*Culture is not the way of celebrating Christmas or not the way of going to school but it is rather setting up the ways of working when you have a distributed organization*". The interviewee Y at company A and interviewee Z believe that the main culture differences are; understanding each other and fulfilling and understanding what the commitment means. The interviewee Y at company A quoted about understanding each other as " *if I say like this and he answers like that then he might not mean that because that is the way their culture is , they say 'Yes' but they have not understood*". Furthermore, the interviewee Y also considered language as one of major issue when communicating each other properly and especially for requirements.

Even though both companies have little bit different perceptions about culture difference but both of these companies thinks culture difference as a major issue when it comes to RU as shown in Table I. Both companies believe that culture difference has created more problems than rewards. Therefore, both companies are now focusing and considering this issue up on the table.

5.2. Geographic Dispersion

The major issue being experienced in both companies due to geographic dispersion is lack of understanding each other in time. Furthermore, the interviewee Z quoted "*If I am wrong tell me how I am wrong, give me some suggestions etc*" and detection of disagreements because it has impact on RU by in large. Likewise, when solving requirements issues it is necessary to understand each other what is individual thinking, meaning and perception about the issue. The reason being lack of understanding each other is mainly due to culture difference, language barriers, trust and commitment. Besides, the interviewee Y told that requirements misunderstanding have impacted their projects by increasing rework and quoted "*I did not mean it; I was thinking it will be like this and this*". Therefore, geographic dispersion is a major issue for both companies as shown in Table I.

5.3. Loss of Communication Richness

Communication is considered as a challenging and important issue for both companies. Both of the companies stressed and focused on visual representations of requirements problems because it is not enough to discuss only on telephone due to the fact that you do not see what other one sees i.e. you cannot locate/pinpoint to the issue. Likewise, language is also considered as a barrier because it is hard to express the requirements which ultimately cause misinterpretations of requirements. In addition, loss of communication richness is also due to less communication and meeting face to face. The interviewee Z quoted on importance of communication as "*I used to stress to call at least once a week to other units even if it is not really important to build a culture so that talking with each other becomes easy. They should not think twice IS IT OK to call Mr.XYZ they should just call because it solves problems much easily*" and interviewee Y claimed on necessity of meeting face to face as "*It is important to meet face-to-face at least once because it is one thing to call someone that you have met with and talk about problems and issues. It is totally different thing to call that person if you have never met him/her*". Moreover, both companies thinks that culture difference has also impact on the richness level of communication because in some countries it is normal to say "*Yes*" even if he/she have not understood the issue in full due to shyness, not to lose their faces

and so on. Therefore, loss of communication is considered as major issue in both companies as shown in Table I.

5.4. Coordination Breakdown

As the geographical distance increases it becomes more and more difficult for organizations to coordinate with each other due to several reasons like lack of communication, lack of collaboration, expert identification and so on. Further, both companies are facing this issue and trying to reduce it with the passage of time. Beside, both of the companies strongly believe that coordination breakdown has impact on RU and occurs mainly due to lack of frequent communication both formal and informal, lack of collaboration, identifying relevant experts, time difference and lack of standardization and so on. Moreover, as requirements conflicts are resolved through close coordination therefore it is necessary to overcome coordination breakdown. Likewise, for RU to reach on consensus and agreement, requires intense communication and negotiation therefore close coordination is necessary for it as well.

5.5. Loss of Teamness

It is quite obvious that as teams are dispersed geographically so therefore there are several reasons which affects the teamness across different units. However, both of the companies believe that loss of teamness has not so much direct impact on RU but due to the fact that key to success is team work. Besides, for RU continuous discussion, negotiation, interaction and communication are needed which are lost when teamness problem arises therefore it cannot be neglected. In both companies teamness is not considered as a major issue. For ensuring teamness they use the good approach of task modularization which helps them in reducing dependency on each other. Further, they have close collaboration and frequent formal and informal discussions to ensure interaction.

5.6. Time Zone Difference

In globally dispersed teams time zone differences exist and increases when it comes between two continents. In both companies time zone difference is considered as an issue but Company A thinks it is a challenging issue because it not only affects team work but also causes delay. Company A thinks that one of the reason due to which organizations adopt offshore is to have round the clock development which in their opinion is wrong and claimed as "*Time difference could be beneficial for us, because we at location X could write the requirements specifications and then we can just send it and a few hours later the team at location Y start working on it and implement it, but I think it is a lie because it does not work that way. In some cases it might works well but in other it will not because what we are doing requires team work. Besides, it's not just to write the requirements and then hand it over to someone and believe that person will understand it as you understood it and implement in that way*". Besides, Company A believes that due to time differences it is always hard to communicate and discuss issues at the same time. Company B believes that time zone is not a big issue for us because our units are not so scattered and therefore our RE activities are not affected as much.

6. Conclusions

In this paper the authors answered the posed research question in two phases i.e. literature review and industrial interviews. First of all a thorough literature study was performed which identified several GSE challenges and their impact on RU. Secondly, industrial surveys were conducted which also identified problems faced in RU due to GSE. Based on the analysis of literature review and industrial interviews the authors have concluded that RU issues in GSE occurs due to lack of communication and knowledge sharing, lack of interaction, culture diversity, lack of mutual discussions, lack of face-to-face meetings, co-ordination and communication breakdown due to time zone difference and loss of teamness.

Our next research study will be focused on providing KM practices/solutions for RU challenges in GSE identified in the current study. Besides, as the authors performed only qualitatively research, therefore, in future a quantitative study is needed. In addition, as authors have only conducted interviews in two industries working in same domain i.e. Telecom, so therefore it would be a nice future work to see the results if the interviews are conducted in more than two industries working in different domains.

7. References

[1] D. Damian and D. Moitra. Global Software Development: How Far Have We Come? *IEEE Software*. IEEE, vol.23, no.5, (2006), pp.17-19.

[2] J. D. Herbsleb and D. Moitra. Global Software Development. *IEEE Software*. IEEE, vol.18, no.2, (2001), pp.16-20.

[3] H. Holmstrom, E. Ó. Conchúir, *et al*. Global Software Development Challenges: A CaseStudy on Temporal, Geographical and Socio-Cultural Distance. IEEE InternationalConference on Global Software Engineering (ICGSE'06), IEEE, (2006), pp.3-11.

[4] D. E. Damian and D. Zowghi. RE Challenges in Multi-site Software Development Organizations. *Requirements Engineering*. Springer-Verlag, vol.8, no.3, (2003), pp.149–160.

[5] D. E. Damian and D. Zowghi. The impact of stakeholders' geographical distribution on managing requirements in a multi-site organization. *Proceedings of the IEEE Joint International Conference on Requirements Engineering (RE'02)*. IEEE Computer Society, (2002), pp.319-328

[6] S. Fricker, T. Gorschek, and P. Myllyperkiö. Handshaking between Software Projects and Stakeholders Using Implementation Proposals. Springer-Verlag Berlin Heidelberg, (2007), pp. 144 – 159.

[7] C. B. Seaman. Qualitative Methods in Empirical Studies of Software Engineering. *IEEE Transactions on Software Engineering*. IEEE, vol.25, no.4, (1999), pp.557-572.

[8] F. J. Fowler, *Survey Research Methods*, Applied Social Research Methods Series Volume 01, Third Edition, Sage Publications, (2002).

[9] G. Kotonya and I. Sommerville. Requirements engineering processes and techniques, John Wiley & Sons, April (1998).

[10] M. Niazi and S. Shastr. Role of requirements engineering in software development process: An empirical study", Multi Topic Conference 7th International INMIC, IEEE, (2003), pp. 402-407.

[11] Jawed Siddiqi and M. C. Shekaran. Requirements engineering: The emerging wisdom. *IEEE Software*. Ebsco, vol.13, no.2, (1996), pp.15-20.

[12] D. Damian. Stakeholders in Global Requirements Engineering: Lessons Learned from Practice. *IEEE Software*. IEEE, vol.24, no.2, (2007), pp.21-27.

[13] Y. Hsieh. Culture and Shared Understanding in Distributed Requirements Engineering. International Conference on Global Software Engineering (ICGSE'06), IEEE Computer Society, (2006), pp.101-108.

[14] D. E. Damian and D. Zowghi. An insight into the interplay between culture, conflict and distance in globally distributed requirements negotiations.*, Proceedings of the 36th Hawaii International Conference on System Sciences (HICSS'03)*. IEEE, (2003), pp.19-28.

[15] F. Prikladnicki, J. Audy and R. Evaristo. Requirements Management in Global Software Development: Preliminary Findings from a Case Study in SW-CMM context. *The International Workshop on Global Software Development, ICSE*, (2003), pp.53–58.

[16] V. Sinha, B. Sengupta and S. Chandra. Enabling Collaboration in Distributed Requirements Management. *IEEE Software*. IEEE, vol.23, no.5, (2006), pp.52-61.

[17] L. Lopes, R. Pridladnicki and J. L. N. Audy. Distributed Requirements Specification: Minimizing the Effect of Geographic Dispersion. *Information Systems Analysis and Specification ICEIS*, (2004).

[18] P. C. V. Fenema. Coordination and Control of Globally Distributed Software Projects. PhD Thesis, Erasmus Research Institute of Management (ERIM).

[19] E. Carmel. Global Software Teams Collaborating Across Borders and Time Zones. Prentice Hall, (1999).

[20] P. G. Smith and E. L. Blanck. From experience: leading dispersed teams. *The Journal of Product Innovation Management*. Blackwell Publishing, vol.19, no.4, (2002), pp.294-304.

[21] E. Carmel and R. Agarwal. Tactical Approaches for Alleviating Distance in Global Software Development. *IEEE Software.* IEEE, vol.18, no.2, (2001), pp.22-29.

[22] D. L. Duarte and N. T. Snyder. *Mastering Virtual Teams: Strategies, Tools, and Techniques That Succeed.* Second Edition, Jossey-Bass Inc, (2001).

[23] M. Vanzin, M. B. Ribeiro, R. Prikladnicki, I. Ceccato and D. Antunes. Global Software Processes Definition in a Distributed Environment. *Proceedings of the 2005 29th Annual IEEE/NASA Software Engineering Workshop (SEW'05)*. IEEE, (2005), pp.57-65.

[24] S. Komi-Sirvio and M. Tihinen. Lessons Learned by Participants of Distributed Software Development. Knowledge and Process Management, vol.12, no.2, *Wiley InterScience*. (2005), pp.108-122.

[25] R. D. Battin, R. Crocker, J. Kreidler and K. Subramanian, "Leveraging Resources in Global Software Development. *IEEE Software*. IEEE, vol.18, no.2, (2001), pp.70-77.

[26] J. D. Herbsleb, D. J. Paulish and M. Bass. Global Software Development at Siemens: Experience from Nine Projects. *Proceedings of the 27th international conference on Software Engineering*. IEEE, (2005).