Guest Editorial

Global Software Engineering: Identifying Challenges is Important and Providing Solutions is Even Better

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1. Introduction

Global Software Engineering (GSE) has become a mainstream trend in industry. An increasing number of companies, irrespective of size and location, have been getting their software developed in an arrangement where a majority of stakeholders are distributed across geographical, temporal, and socio-cultural boundaries. The transformation of GSE from a phenomenon to a paradigm has been spearheaded not only by business needs and organizational desires but also consistent efforts of the GSE community. There has been a dedicated conference series to this area, the International Conference on Global Software Engineering (ICGSE) and its 6th edition provided the two articles that have been included in this special section. This editorial aims at not only to introduce the two articles included in this special section but also to report a sample of the topical trends of research published in the ICGSE series on challenges identified and solutions. It is quite clear that there was a huge amount of efforts dedicated to identifying and reporting GSE challenges but the community has been slow on reporting potential solutions to the known challenges. Whilst it is important to make researchers and practitioners aware of the potential challenges and risks, it is even better to systematically devise, empirically assess, and sufficiently report solutions to the known challenges. Through this editorial we also introduce a framework of ten heuristics for devising, developing, and managing a GSE team for successful implementation of the GSE paradigm in an organization.

2. Thematic Trends of Research Published in ICGSE

Not always but most of the time, GSE projects tend to be large and complex with several dozens of stakeholders who may have to face several kinds of challenges characterized by the need of new and novel coordination, collaboration, and communication mechanisms [1], [2], [3]. As previously mentioned, ICGSE has played an important role in building a body of knowledge about the potential GSE risks and challenges related to communication, coordination and control caused by temporal, geographical and socio-cultural distances. It was deemed appropriate to review the topical trends of a selected set of papers from previous ICGSE conferences. For this purpose, we decided to randomly selected 10 research papers from each of the ICGSE conferences between 2006 and 2011 and perform a shallow thematic analysis to identify the topical trends and categorize the selected papers. Table 1 shows the themes and trends that have been identified. Following is the brief description of each of the themes and the relevant papers.

Communication: There has been a lot of effort dedicated to study communication in the context of GSE. We identified 11 papers from ICGSE specifically investigating communication matters. The covered topics ranged from the perspective of the role and choice of communication media [4], [5], [6], [7] to browsing into the communication patterns [8], [9] and associated challenges and solutions [10-12].

Coordination: We could only identify 3 papers specifically studying coordination in GSE. It is interesting to note that coordination is a hugely researched topic in virtual teams but there has not been much research reported in ICGSE series. The identified papers covered issues such as roots of coordination breakdown in GSE [13], provision of solutions in form of practices [14] and coordination index [15].

Collaboration: It is well known that software engineering is a collaboration-centric activity that can be negatively impacted by distribution factors in GSE. The ICGSE has published several papers reporting different kinds of challenges, which are directly or indirectly, related to collaboration among GSE project team members. We have identified 9 papers (i.e., shown in Table 1) that mainly focus on different aspects of the collaborative challenges and potential solutions in GSE.

Table 1: Thematic distribution of the reviewed studied published in ICGSE between 2006 and 2011.

Themes		**Number of primary studies**	**Primary studies**
Communication		11	[6], [11], [5], [12], [7], [4],[10],[9] , [8], [16], [17]
Coordination		3	[15], [13], [14]
Collaboration		9	[18], [19], [20], [21], [22], [23], [24], [25], [26]
Software Development Governance in GSE [27]	GSE Models and Processes	12	[28], [29], [30], [31], [32], [33], [34], [35], [36], [37], [38], [39]
	Project Management in GSE	11	[40], [41], [42], [43], [44], [45], [46], [47], [48], [49], [50]
	General GSE Practices	8	[51], [52], [53], [54], [55], [56], [57], [58]
	Knowledge Management (KM) in GSE	5	[59], [60], [61], [62], [63]
Total		60	

GSE Models and Processes: This sub-category contains the papers reporting topics such as reference models for successfully conducting GSE [28-29], business strategies [30], process descriptions [32] and the issues associated with software development processes such as requirement engineering [34], [33], design [23] and software architecture evaluation [35].

Project Management in GSE: This sub-category includes all the papers discussing the topics for managing GSE projects such as conducting Scrum practices [40-43], risk management strategies [44-45], and relevant models provided for task allocation [46-47], effort estimation [48] and process description.

General GSE Practices: This theme describes the papers covering general GSE practices such as the challenges and benefits of applying agile approaches in GSE [54], [55], the guidance for successful product transfer [51], and more generic topics such as the suitability of the roles in distributed arrangements [52], the interdependency of distribution dimensions [53], and the challenges and successful practices associated with distributed testing [56].

Knowledge Management (KM) in GSE: This theme covers the papers either targeting architectural knowledge management specifically [61], [62], [60] or discuss the impact of different factors and circumstances associated with distributed development such as organizational decisions [59] and culture [63]on managing knowledge.

Apart from thematic trends of GSE research identified from the randomly selected 60 papers published in ICGSE 2006-2011, it would also be appropriate to indicate that there was a panel discussion during ICGSE 2011 on the "***Unique challenges of GSE in Europe***". The motivation for this panel came from our observation that there had been relatively less attention to the unique challenges caused by a particular geographical location, for example Europe. The panel discussion resulted in the identification of two key GSE challenges where European nuances appeared significant and important to address:

- Cultural issues in the context of Europe are complex as there are several dozens of different cultures within Europe itself let alone the cultural diversities that characterize GSE. It was felt that whilst the general level of maturity to deal with culture specific issues has increased over the last decade, the challenges related to cultural issues in general and in an European context in particular cannot be underestimated. One solution to address country- and company-specific cultural issues

is to take equality partnership approach. It was recognized that client and vendor relationships are very much transaction oriented and does not encourage investigation of time and energy in identifying, understanding, and addressing cultural challenges.

- Language related issues can have more GSE challenges for Europe than other parts of the World. It was felt that native English speakers can understand different accents in general and strong Asian accents in particular with relatively less amount of time and effort as compared to their European counterparts. It was argued that US companies are diverting most of their outsourced software development and maintenance to India because the USA companies and their staff have more cultural similarities or understandings of Indian business models and software development professionals compared with their European counterparts. It was also pointed out that the emerging trend among USA companies of near-shoring to South American countries has been motivated by cultural and language similarity in general.

2. Strategies for Taming GSE Challenges

In our observation, there are four key areas that determine how difficult a GSE project is (Figure 1).

- Sites: The geographic distribution of team members, working in different time zones and cultural differences impede the collaboration.
- Target system: In particular non-functional requirements such as performance or security frequently impact large parts of the target system and hence multiple sites. The software architecture of the target system significantly determines the dependencies between parts of the system, which implies the need for communication.
- Organization: Processes and IT infrastructure are the basis for the work of global teams. If all team members are working on the same goal depends on the targets of the organizational units and sites as well as the prevailing incentive structures.
- Employees: The language skills and communication abilities of the employees, their technology and domain knowledge as well as their experience with distributed projects have significant influence on the collaboration.

Based on our experiences of numerous GSE projects, observations from conducting dozens of empirical studies of GSE projects, and an extensive review of literature, we have identified ten heuristics for devise and deploy appropriate strategies in each of the abovementioned four key areas of GSE. These heuristics are expected to help managers to carefully plan, organize, and manage GSE projects and successfully dealing with the challenges that usually characterize GSE projects.

1. Plan the distribution deliberately.

Plan the software architecture and distribution of tasks deliberately in order to reduce dependencies [64],[65]. Ambiguities in the software architecture or unclear responsibilities as well as belated changes cause a high need for communication. While an “extended workbench” approach in practice is often used to get into global software engineering, this work split according to process steps is frequently rather unfavourable. For example, if analysis and design are conducted in Germany, the coding takes place in India and the subsequent test and integration is carried out in Germany, this leads to a high need for communication across sites. It is often more reasonable to establish centres of competence which are in charge of whole subsystems.

2. Start locally and grow globally.

In particular in case of new, innovative projects, where there is less experience with the technology or team constellation, it is advantageous to start the project locally at one site and grow it globally later on. In this way during the communication-intensive start up phase relevant design decisions can be made and the team building can be furthered [19, 66-67].

3. Carefully select employees and prepare them for their tasks.

The work in globally distributed teams requires high flexibility and distinct soft skills [68], [69], [70]. Employees shall be carefully selected under these considerations in order to achieve high team coherence. Ensure a sufficient qualification of team members, e.g. via training and certification in project management, software architecture, requirements engineering and testing. Enable the team members for intercultural collaboration, e.g. via an intercultural training or communication training. Assign a team mentor who passes on his or her experience with globally distributed projects.

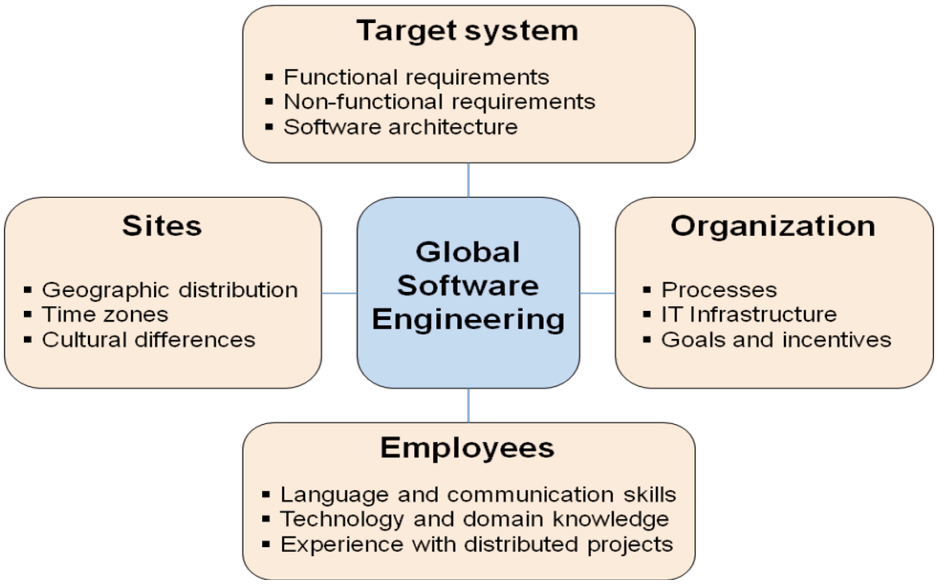

Figure 1: Influencing Factors of GSE

4. Establish a common goal.

It is important to establish a common project identity and a common goal across sites. Ensure that all sites follow the same targets and set up suitable incentive structures. Strong management support is essential [70-71].

5. Further the exchange of employees.

Trust between project managers is the basis for an open communication and good collaboration. Further the exchange of employees across sites, e.g. via delegation. In important phases of the projects also physical meetings of the team members of the various sites can be very helpful [66], [19], [70], [67].

6. Provide a suitable IT infrastructure.

Because the collaboration across sites occurs via virtual communication, a reliable IT infrastructure is the prerequisite. This requires amongst others compatible development environments, high availability and suitable communication tools. Special collaboration tools can support virtual teams in their collaboration and help them to be well informed about the work of the distributed colleagues [70], [72].

7. Define clear communication structures and a global escalation path.

Develop a communication plan with an overview of all persons involved in the project and communication structures: Who are the stakeholders and which information needs do they have? Who needs when to be informed about what? How can the communication be ensured most effectively? Define a clear escalation path across sites to ensure that problems can be address early on [66], [71] .

8. Utilize time zone differences.

Different time zones and working hours impede the reachability of the distributed colleagues. Define time slots, where a spontaneous contact (e.g. phone call, online chat) is possible. Utilize the global distribution to conduct tasks "over night", e.g. the test of new components so that the results are available on the following morning [73], [74].

9. Pay attention to clear requirements and domain knowledge.

The requirements are the basis for what is implemented in a project. They have to be clear, understandable and unambiguous. The right understanding of the requirements is the prerequisite for the success of the project. Unclear or conflicting requirements lead to a high need for communication; in the worst case the requirements are implemented in the wrong way or incompletely. Missing domain knowledge makes the communication more difficult and increases the need for specifications and explanations. Ensure that requirements are clearly defined and that all team members have sufficient domain knowledge [75], [71] .

10. Use an iterative process and foster continuous improvement.

By using an iterative process it can be ensured that work products are developed step-by-step and hence can be reflected early on. Also agile approaches like Scrum have proven to work well in distributed teams, because they foster the communication across sites. Use project retrospectives in order to analyse problems in the project and address them [76], [73].

4. Articles in this special section

For this special section, we decided to invite only those two papers that gained the highest ranking by the reviewers and program committee chairs. These two articles deal with two of most important issues in GSE: cultural aspects of software testing and creating alignment among stakeholders of a GSE project.

The paper "*Global software testing under deadline pressure: Vendor side experiences*" by Hina Shah, Mary Jean Harrold and Saurabh Sinha [77] presents the findings from an empirical study of a vendor organization's testing team. This work investigated the challenges that testing engineers encounter while working under deadline pressure. The findings show that quality of testing could be affected by multiple factors such as motivation of testers and their dilemma in performing high-quality work under tight deadlines. The authors also underline how the team structure can negatively impact work quality by increasing deadline pressures. The authors also present how productivity could be perceived differently in dissimilar cultures and result into "unproductive productivity". The findings highlight the importance of cultural aspects of software testing in GSE. The work also highlights the role of appropriate team structures in reducing pressure and facilitating high-quality work.

The paper "*Software quality across borders: Three case studies on company internal alignment*" by Sebastian Barney, Varun Mohankumar, Panagiota Chatzipetrou, Aybuke Aurum, Claes Wohlin and Lefteris Angelis [78] aimed at investigating a) the level of alignment between key stakeholders in prioritizing different aspects of quality in the project and b) the factors that impact the level of alignments. The findings revealed that there can be various levels of alignment between various groups that result from factors such as cultural differences, short-term vs. long-term orientation, communication and coordination. According to the authors, cultural variances, work distribution strategies, and loose-coupling may cause mis-(alignments) of product quality. The overall conclusion highlights the importance of developing a shared understanding among success-critical stakeholders of company regarding quality in offshore software development.

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