IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

Received May 24, 2021, accepted June 15, 2021, date of publication June 22, 2021, date of current version July 26, 2021.

Digital Object Identifier 10.1109/ACCESS.2021.3091603

A Conceptual Model to Address the Communication and Coordination Challenges During Requirements Change Management in Global Software Development

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The work of Saim Qureshi was supported by the COMSATS University Islamabad, Pakistan.

ABSTRACT Global Software Development (GSD) is a widely used development practice because of various advantages offered to the customers, vendors, and other stakeholders involved in a software project development. However, GSD is not a simple process as it faces multiple challenges that arise due to the mismanagement of the communication and coordination process. Meanwhile, Requirements Change Management (RCM) is a tedious and high resource-consuming process in GSD, which is further negatively affected by the poorly managed communication and coordination mechanisms. Multiple research studies have presented various theoretical and conceptual models to overcome the challenges during RCM in the GSD context. However, the current methodologies lack in handling the communication and coordination challenges during the RCM process in the GSD context. In the literature, the researchers have concluded that a conceptual model can effectively reduce the communication and coordination challenges during RCM in GSD. Inspired by this, the current work aims at proposing a conceptual model to overcome and mitigate the communication and coordination challenges, while ensuring the effective requirement changes at offshore software development sites. Moreover, it would help multiple stakeholders in understanding and managing the necessary resources before initiating the RCM process. To validate the proposed conceptual model, we have conducted a questionnaire-based survey to procure the results from the industrial experts working in the GSD domain. After analyzing the obtained results, we found that the proposed conceptual model is effective to handle the communication and coordination challenges up to 87%. In addition, almost 87% of the experts have agreed upon the correctness, identified challenges, and the mitigation practices in the proposed conceptual model necessary to improve the RCM process in the GSD context. Furthermore, it was observed that 75% of the experts also agreed upon the practical implementation of the proposed conceptual model in the software development industry to observe the heuristic performance of the proposed conceptual model.

INDEX TERMS Global software development, requirements change management, communication challenges, mitigation practices, conceptual model.

I. INTRODUCTION

Global Software Development (GSD) is a widely adopted and appreciated practice to achieve numerous development benefits such as reduced development time, cost, and accessing the best global development teams [1]–[7]. The GSD process has attained global recognition since current software development and the related activities can be performed at distributed geographical locations. [8]. In this context, the GSD has proven to be the best option to achieve valuable benefits including business benefits, competitive advantages, and multiple solutions for single or multiple problems [9]. Figure 1 highlights the major benefits of GSD that attract multinational organizations to outsource

The associate editor coordinating the review of this manuscript and approving it for publication was M. Anwar Hossain.

the software products from other countries. The major benefits include accessing highly skilled software developers, cross-site software development, innovation and shared practices, closer proximity to clients and markets, reduced development time and cost, and time zone effectiveness (Figure 1).

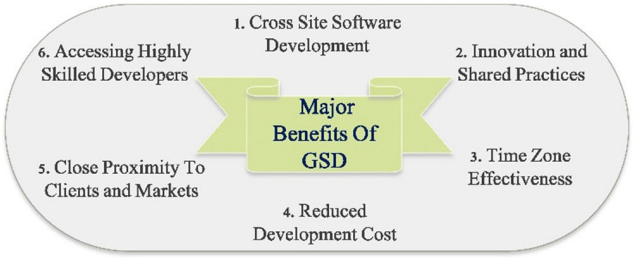

FIGURE 1. The Key benefits of GSD Environment.

It is pertinent to mention that requirements change in any software development process is a major and complex activity [10]. The need for requirements changes could occur at any stage during the software development, and these changes must be managed and implemented properly and effectively [11]. In the literature, different factors have been mentioned that force initiation of the requirements change management process. The factors include the technological changes, clients' new demands, organizational or government policy changes/revisions, budget or time constraints, the effect of human resources [10]–[14]. For the successful implementation of a new requirement(s), a properly managed requirements management process is crucial [15]. The unanticipated software requirements changes are considered a high resource-consuming and exasperating process [16]. An effective RCM process in GSD firmly relies on an effective communication and coordination mechanism between multiple dispersed locations [16]–[20]. Communication and coordination are among the loftiest and regarded as highly resource-consuming challenges while analyzing and managing the newly initiated requirements change requests [21]–[23].

Due to the lack of proper communication, the newly commenced changes in requirements are not transferred to multiple offshore development teams and can cause misunderstandings among multiple stakeholders [23]. Evidently, lack of proper communication and coordination among stakeholders creates multiple challenges in requirements negotiation, requirements transfer, and lacking mutual trust among all stockholders in a software project [15], [24], [25]. Proper and synchronous communication channels, tools, and methodologies are of vital importance to effectively manage and implement the requirements changes in a software product [26], [27]. Through a conceptual model or framework, the newly introduced requirements can be constructively transferred to all the stakeholders to avoid the multiple conflicts that arise while sharing the requirements change [28]. A specifically designed conceptual model for the globally distributed RCM process can help the stakeholders to effectively and effectively reduce the communication and coordination challenges to productively implement the newly introduced requirements at the multiple offshore located software development sites [6], [29]–[35].

Figure 2 presents a high-level view of the RCM process in the GSD context. According to Figure 2, a client initiates a change request to an outsourcing organization at location 1, which is analyzed to view the need for a change request, and approves or rejects the change. If approved, the changes are forwarded to multiple organizations and individuals (including the project managers) to implement the desired changes at location 2 and location 3 in different countries.

It can be observed that the outsourcing organization has multiple staff, including a Change Control Board (CCB),

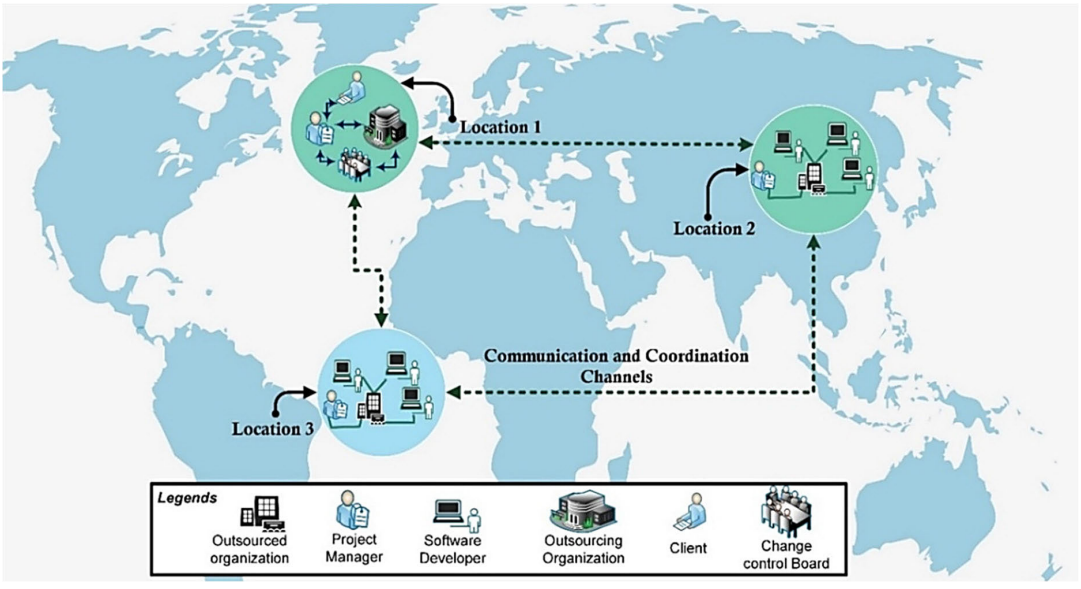

FIGURE 2. Overview of RCM process at globally distributed sites.

software developers, and a project manager to monitor the software project manager's to handle the challenges by judiciously consuming the development resources in the distributed development environment. Overall work progress at multiple distributed sites (Figure 2).

A. RESEARCH CONTRIBUTIONS

The following are the main research contributions of the current work:

1) Outlines an improved methodology to the software development organization and software developers to effectively manage the valuable resources before implementing the RCM activities in GSD.
2) Propose a comprehensive conceptual model to mitigate the communication and coordination challenges during the RCM process in GSD.
3) Validates the proposed conceptual model using industrial experts-based validation technique to increase the organization's acceptance rate.

The subsequent sections are structured as follows. Section II provides an overview of the background motivation for this research, while the adopted research methodology is provided in Section III. In contrast, Section IV discusses the methodology of the validation process, and related work is highlighted in Section V. Section VI presents the proposed conceptual model and relevant details. Similarly, Section VII discusses the results and analysis, and Section VIII presents the threats to validity. Section IX outlines the research implications. Finally, Section X presents the conclusion and future work.

II. BACKGROUND AND MOTIVATION

Communication and coordination are the main challenges for any software organization that must be well understood and mitigated before the initiation of any software project [27]. In Distributed Software Development (DSD), the physical separation of software stakeholders, including geographical distance, temporal distance, and cultural differences, are the key barriers to manage the new requirements [36]. We have conducted a tertiary study in which 27 Systematic Literature Review (SLR) studies were analyzed, and 75 communication and coordination challenges were discovered along with 107 mitigation practices. It is worth mentioning that after the analysis, it was observed that no study comprehensively highlighted communication and coordination challenges during RCM in GSD. Even some studies briefly highlighted the RCM challenges in a generic way. Furthermore, it was also observed that there exists no conceptual or theoretical model or framework to reduce the communication and coordination challenges while managing the requirements change in GSD. The analyzed limitations in the current state-of-the-art literature motivated us to propose a conceptual model to effectively address the challenges that occurred during RCM in the GSD context. As a result, it would enable the practitioners to overcome the discovered communication and coordination challenges during the RCM process which require more attention and more reliable mitigation techniques. Furthermore, as previously mentioned, coordination among the stakeholders is the least addressed challenge while performing the RCM process in the GSD context. The domain was finalized based on the previous background knowledge and analysis of multiple studies that focused on the challenges during the RCM in GSD.

III. RESEARCH METHODOLOGY

Based on the analysis of the limitations in existing conceptual models, a new challenge and respective solution-oriented conceptual model was designed to overcome the limitations in the existing models and techniques. Figure 3 highlights the steps of the adopted research methodology. There were nine steps followed to conduct this research that starts from analyzing the selected problem domain to report the final results of the proposed conceptual model (Figure 3). In total, 75 major communication challenges along with 14 major coordination challenges were discovered after analyzing the 27 SLR studies. There were 107 mitigation practices highlighted in the 27 different studies. In addition, some research studies also discussed the conceptual models and frameworks to reduce the challenges.

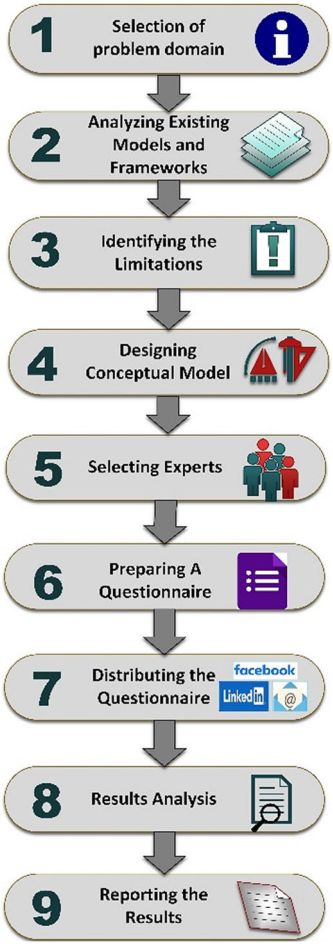

FIGURE 3. The adapted research methodology.

The following sections discuss the steps of the adopted research methodology.

A. SELECTING PROBLEM DOMAIN

To start the targeted research process, the existing literature in GSD was identified. After a comprehensive analysis of the multiple studies and challenges in the GSD context, it was discovered that the communication and coordination challenges require more attention while managing the RCM process in the GSD context.

B. ANALYZING EXISTING MODELS AND FRAMEWORKS

In this step, a comprehensive analysis of the existing studies in the GSD context was performed. The articles mainly highlighted the challenges, problems, issues, and barriers during the requirements change management and control process at distributed locations. Hence, we analyzed the studies that presented the challenges, conceptual models or frameworks, and multiple mitigation practices during RCM in the GSD context only. The key purpose of this step was to observe the proposed methodologies and conceptual models as mentioned by the authors in the literature.

C. IDENTIFYING THE LIMITATIONS

Multiple frameworks and models are of greater importance to overcome the challenges and to improve the multiple activities performed in GSD. The existing conceptual models and mitigation frameworks in the literature were carefully analyzed to identify the potential limitations based on which the proposed conceptual model was designed and presented in this study.

D. DESIGNING THE CONCEPTUAL MODEL

To overcome the identified limitations in the existing mitigation frameworks and models, a novel conceptual model was proposed to effectively reduce the limitations and shortcomings in the existing models. The proposed model is based on the challenges and mitigation strategies during the RCM process management in GSD. The underlying objective is to enhance the RCM implementation process at multiple geographical locations by the software development organizations and individual software developers.

E. SELECTING THE EXPERTS

For the validation of the proposed conceptual model, we have consulted eight industrial experts selected from multiple countries having a strong knowledge about the GSD domain and RCM process (Table 1). The experts analyzed the proposed conceptual model, and the results and feedback from the experts were recorded accordingly. Note that multiple social networking tools, including Facebook and LinkedIn, were utilized to identify the most suitable industry-based experts.

TABLE 1. Organizational background and relevant work experience of the selected experts.

No.	Organization/ Institute name	GSD Work Experience	Country
1	Talent Alpha	7 years	Poland
2	Netsol Technologies	5 years	Pakistan
3	Rocktough Tech.	4 years	Pakistan
4	Ericsson Pakistan	9 years	Pakistan
5	Individual (freelancing)	7 years	Pakistan
6	Dtech Systems	5 years	Saudi Arabia
7	Ikontent Digital Europe Ltd.	6 years	Hungary
8	Virtusa AB, Sweden	11 years	Sweden

F. PREPARING THE QUESTIONNAIRE

A predefined questionnaire for the validation of the proposed model was developed using the guidelines mentioned in the studies [37], [38]. Multiple questions-based questionnaires containing the 12 open and nine closed-ended questions were designed via utilizing Google forms. Finally, a predesigned questionnaire was finalized for distribution among the selected experts. The finalized questionnaire[1] is mentioned in Appendix B.

G. DISTRIBUTING THE QUESTIONNAIRE

Multiple social networking sites, including LinkedIn and Facebook, were used to distribute the designed questionnaire to the industrial experts.

H. RESULTS ANALYSIS

The outcomes acquired from the eight industrial experts after the model's validation process were recorded. The total responses from the experts, including the open and closed-ended questions, were examined. The insignificant just as inadequate inputs were barred. Finally, the obtained results were analyzed by using the designed MS Excel.

I. REPORTING THE RESULTS

In this phase, the results obtained from the experts after the validation process are mentioned. Table 2 reports the obtained validation results. The results included the information about the experts' jobs, countries, experience, and the evaluation-based information of the conceptual model.

IV. VALIDATION PROCESS

Figure 4 shows the overview of the experts' validation process in which four major steps are being performed. The validation procedure relies on the responses to the questions that were asked to the experts. The questions included the personal information and views of the experts after analyzing the proposed conceptual model.

The four major steps performed during the validation process are mentioned as following:

[1]https://docs.google.com/forms/d/e/1FAIpQLSezn7jJ71QHFbvCI23jJvyag6fAc2o5bwvXW7Tl6AsaRF60Dg/viewform?usp=pp_url

(i) Based on the preliminary design of the proposed conceptual model, a questionnaire-based survey was formulated to obtain the validation results from the experts. Note that we followed the additional guidelines mentioned in [39], [40] were followed to design the questionnaire.
(ii) The predesigned questions were shared as a questionnaire with multiple experts located in different countries via social networking tools, including Facebook, LinkedIn, and emails.
(iii) The experts validated multiple aspects of the proposed conceptual model based on the experience in the GSD context as highlighted in Figure 4.

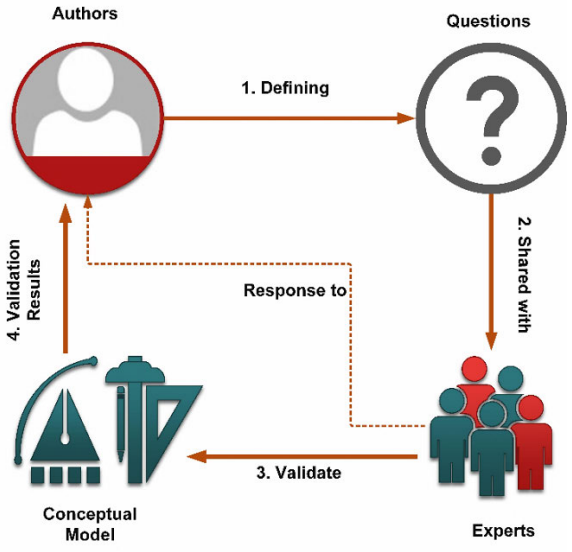

FIGURE 4. Validation process of the proposed conceptual model.

(iv) Finally, the validation results were recorded and analyzed to discover multiple anomalies and redundancies along with incomplete responses from the experts. The final data after the cleansing process was recorded in multiple tools, including the Excel and SPSS tools. The final results are presented in Table 2.

V. RELATED WORK

This section highlights the previously proposed conceptual models and frameworks that have focused on multiple communication and coordination challenges related to RCM and global software development and some major limitations uncovered while analyzing the proposed conceptual models were also highlighted. Only the proposed conceptual models and frameworks were analyzed and discussed in this section.

Khan and Akbar [12] proposed a framework that addresses the challenges as the key motivators of requirements change management. The framework is based on six common challenges, but it still lacks some other challenges. At the same time, there are no mitigation methodologies discussed or highlighted to reduce the communication and coordination challenges. Furthermore, the proposed framework is not suitable enough to comprehensively mitigate the RCM challenges in the GSD context.

Akbar *et al.* [13] uncovered the ten commonly faced challenges related to project administration based on which, Software Requirements Change Management, and Implementation Maturity Model (SRCMIMM) was proposed to mitigate the identified challenges. The proposed model did not highlight the communication and coordination challenges specifically.

Bhatti [14] The proposed theoretical framework tackles only four major challenges, including stakeholder involvement, articulation, technology, and information. It lacks coordination challenges in GSD. Besides, the proposed model does not help mitigate the communication and coordination challenges effectively.

Kamal *et al.* [34] A theoretical framework was proposed to manage the agile software development-based challenges. In the proposed framework, a prioritizing hierarchical structure was proposed to present software methodology and human resources as the most important factors that must be handled effectively while managing the requirements. The proposed model lacks clear understandability of other factors besides human resources. Subsequently, the proposed framework lacks the mitigation of coordination challenges. Furthermore, the proposed framework is not effective for mitigating all RCM based challenges faced in GSD.

Abrar *et al.* [35] proposed a framework based on multiple solved and unsolved challenges via literature analysis. The proposed model is based on heterogeneous solutions to reduce the communication challenges. However, some communication challenges still need to be added as the mentioned challenges and mitigation practices are inadequate to effectively enhance the communication process. Another limitation is that coordination challenges are not addressed in the proposed model. Furthermore, the model lacks the solutions for requirements change management as this model highlighted the RCM process generically. The proposed model is based on survey results only, while no validation process and results of the model were mentioned.

Khan [41] proposed an abstract framework that is based on the analyzed impact percentage of three factors (geographical distance, temporal distance, and socio-cultural difference) after conducting interviews with some employees in an organization. The framework addresses the three highlighted and major communication challenges only while it does not address the other communication challenges. Besides, the proposed framework partially addressed the three identified and major challenges. In addition, only a few sub-challenges of geographical distance, temporal distance, and socio-cultural distance were presented in the framework. Another limitation of the proposed framework is that it does not consider the coordination challenges. Furthermore, the proposed framework was presented as an abstract framework only.

Schneider *et al.* [42] highlighted 127 generic solutions for GSD challenges and presented a framework called

Process Area Management (PAM) used to overcome the GSD challenges. The proposed model does not exclusively handle the communication and coordination challenges; rather, it focused on generic or commonly faced challenges. Furthermore, due to the complexity of the proposed conceptual model, the performance of the proposed conceptual model can be compromised.

Ammad *et al.* [43] proposed a theoretical framework based on multiple communication challenges only. The framework does not highlight all possible communication challenges as some commonly faced communication challenges were not addressed. Furthermore, there were no coordination challenges tackled by the proposed framework.

Akbar *et al.* [44] presented a framework based on the 5 major categories of communication challenges and 3 coordination challenges. The proposed framework does not mention all the possible communication challenges as the mentioned communication challenges are limited to 5 categories only. In contrast, three coordination challenges were not adequate to effectively manage the communication and coordination challenges during RCM challenges in GSD.

Minhas *et al.* [45] proposed a framework to reduce the different challenges faced during RCM in GSD. Still, the proposed framework lacks some communication and coordination challenges along with mitigation strategies, also the proposed framework focused on the overall methodology of managing the requirements change in GSD.

Shameem *et al.* [46] conducted an SLR-based study in which a hypothetical model was proposed to present the relationship of each challenge positively and negatively with the humans. The model is based on 11 challenges that partially mitigate the challenges during the RCM in GSD. Furthermore, the proposed model lacks some major challenges in the RCM process.

Based on the analysis of the current state-of-the-art, we observed as per our best knowledge that there is no proposed model that can comprehensively handle the communication and coordination challenges during the RCM process in the GSD context.

VI. PROPOSED CONCEPTUAL MODEL

One of the significant commitments of this study was to propose a conceptual model for the mitigation of communication and coordination challenges. The key objective of the proposed model is to support the software development practitioners, stakeholders, and different academic-related researchers to effectively and efficiently manage the resources to achieve the crucial milestones during the RCM phase in GSD to conserve the valuable resources including time, cost, and human resources. As already discussed, no existing conceptual model or framework addresses the reduction or minimization of the communication and coordination challenges in distributed or offshore software development.

The proposed conceptual model is based on a literature review and limitations identified from previous literature that motivated us to propose a better conceptual model that effectively overcomes the limitations in existing conceptual or theoretical models. In addition to this, a questionnaire-based survey was conducted and reviews from eight industrial

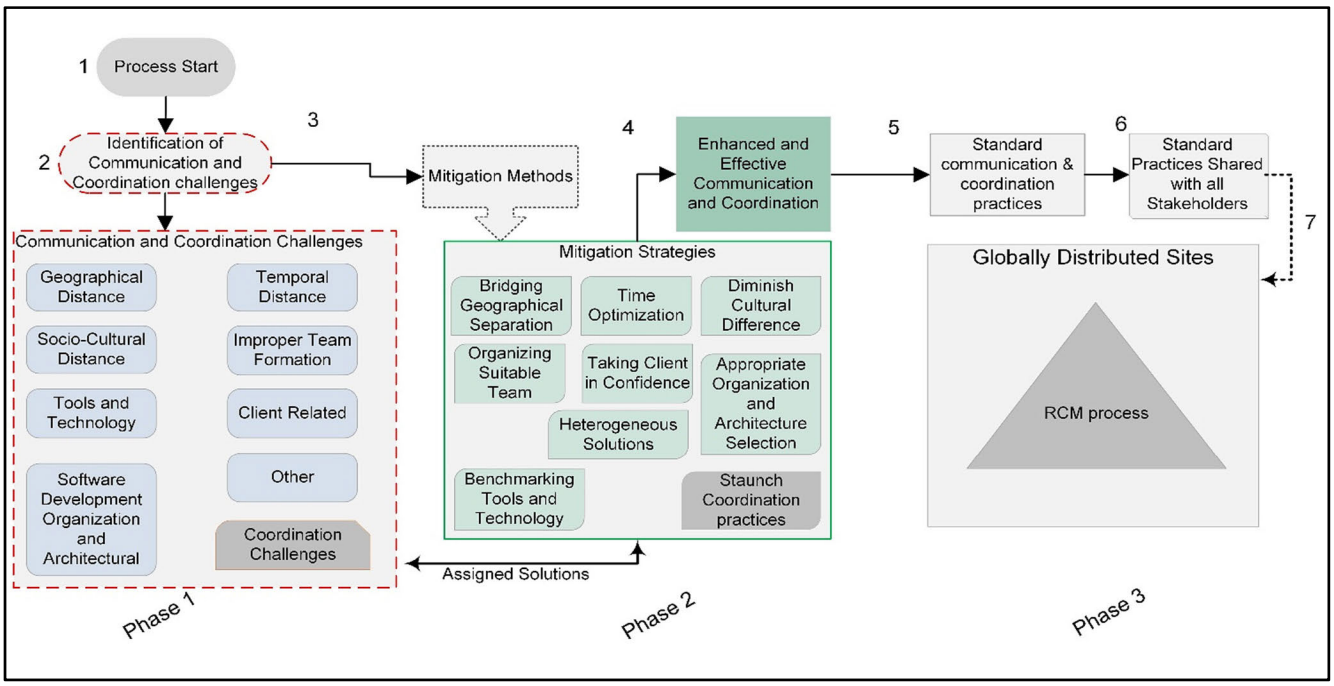

FIGURE 5. High-Level view of proposed conceptual model.

experts were sought to validate the performance of the proposed conceptual model.

Figure 5 presents the abstract view of the proposed conceptual model. The proposed conceptual model consists of three major phases.

- Phase 1: identification and categorization of communication and coordination challenges.
- Phase 2: identification and allocation of mitigation practices.
- Phase 3: the implementation of mitigation strategies at offshore software development and management sites.

A. DETAILED DESCRIPTION OF PROPOSED MODEL

In the detailed version of the proposed conceptual model, the different phases were comprehensively elaborated with additional details about the challenges, mitigation strategies, and requirements change management process at distributed development sites. It consists of eight categories of communication challenges and the corresponding communication solutions. In contrast, there is only one major category of coordination challenges and its solution. The model contains a detailed view of the RCM process in the GSD context.

Figure 6 highlights the detailed view of the challenge-solution-based proposed conceptual model effective to handle the communication and coordination challenges by suggesting the most suitable mitigation practice during RCM in the GSD context. The proposed conceptual model is based on three key phases: a set of sequential steps to achieve the required research objective.

Phase 1 presents the initiation of the process, which is actuated once the need for requirements change management is identified (step 1). Multiple stakeholders in the offshore software development can initiate the requirements change request. But most commonly only clients do so. Next, multiple potential communication and coordination challenges are viewed that can halt the communication process in the offshore requirements change implementation process (step 2). As previously mentioned, we had discovered 62 and 14 different communication and coordination challenges (respectively) through the conducted systematic review. Finally, in phase 1, after identifying the multiple communication and coordination challenges, the corresponding mitigation strategies are identified and utilized (step 3).

In Phase 2, the finest and suitable possible mitigation practice(s) is/are assigned to the specific challenge out of 107 discovered mitigation practices (step 4) to productively handle the discovered challenges in the RCM process. The key purpose of phase 2 is to address each possible communication and coordination challenge that was previously found in phase 1.

Finally, in Phase 3, a standard list of suitable mitigation practices assigned to multiple communication and coordination challenges is transferred to all the offshore stakeholders as a standard set of solutions (step 5). Based on the standardized communication and coordination practices, new change implementation protocols are adapted at all the offshore sites to avoid any communication and coordination challenges during RCM in GSD (step 6). Lastly, the requirements are implemented and managed under predefined communication and coordination standards at multiple offshore distributed locations (step 7).

VII. RESULTS AND ANALYSIS

This section presents the results obtained after a thorough analysis of the data received from the experts. We selected the results from the eight industrial experts who have validated the proposed conceptual model. The responses of experts were recorded and analyzed to generate the results for validity purposes.

A. DEMOGRAPHICS OF EXPERTS

The designed questionnaire was distributed to multiple experts via email, LinkedIn, and Facebook. The experts chosen were based in multiple countries, including Pakistan, Sweden, Saudi Arabia, Poland, and Hungary (Figure 7).

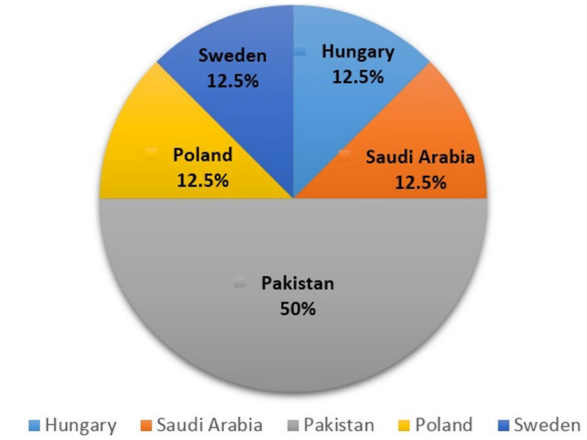

FIGURE 7. The demographic locations of the industrial experts.

B. UNDERSTANDABILITY OF GSD CONTEXT

For the survey, the most suitable experts from the software industry were selected who had a minimum of four years of relevant experience in GSD. We excluded the experts from other domains, including traditional or in-house software development. Figure 8 presents the percentage of the selected experts who had experience in global (or distributed) software development.

From Figure 8, it can be observed that all of the selected experts had clear knowledge about offshoring and globally distributed software development. As previously mentioned that we have excluded the experts that lack in having the GSD knowledge in order to enhance the validity of this research and improve the result's outcomes.

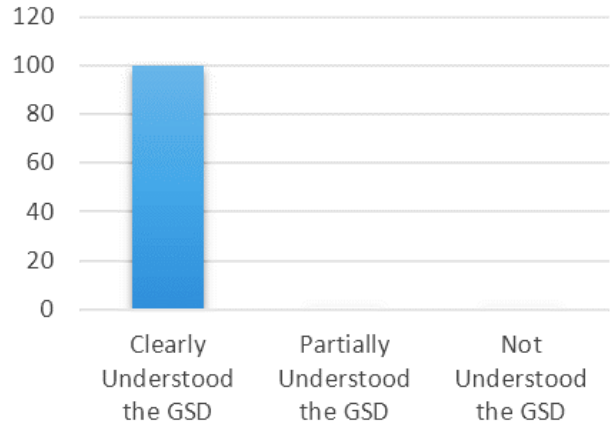

FIGURE 8. The Selected Expert's Understandability about GSD.

C. ORGANIZATIONAL BACKGROUND

The selected experts were either working in the software development organization or individuals, including freelancers. Figure 9 presents the type of organizations of relevant experts. Seven experts were from software development organizations, and one expert was an individual who was developing software or a component for offshore clients.

Furthermore, the names of software development organizations and the experts' experience level are highlighted in Table 1. Besides, we excluded the experts having no experience in GSD. Moreover, the experts having only in-house software development were excluded.

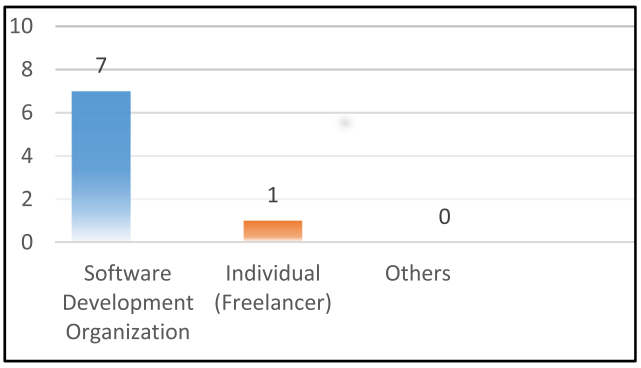

FIGURE 9. Organizational background of the selected experts.

D. EDUCATIONAL BACKGROUND

Based on the selection criteria for the experts, we included those experts only who had educational backgrounds in software engineering, computer science, and information technology only. Figure 10 presents the educational backgrounds of the selected experts.

Consequently, we excluded all other experts who had an educational background in business sciences, computer engineering, and other educational domains. They were not qualified to fill in the required criteria. In summary, we found four experts from software engineering, three experts from computer science, and one expert having an information and technology educational background.

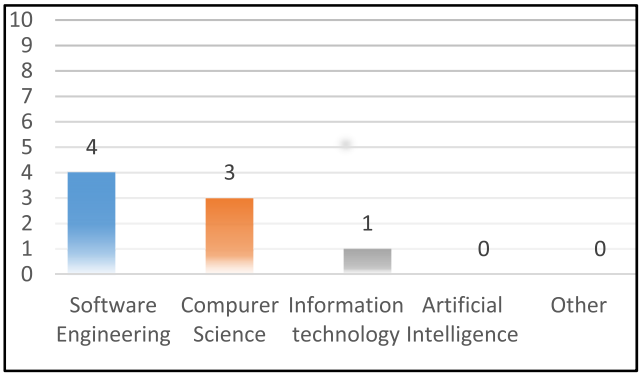

FIGURE 10. Educational background of selected experts.

E. VALIDATION RESULTS

Table 2 shows the eight questions asked in the designed questionnaire and the results obtained from the experts through a questionnaire. The experts answered the questions, and the results were gathered, analyzed, and reported in Table 2. There were 12 closed-ended questions asked to the experts. The questions about the readability, understandability, and logical correctness presented that most of the experts understood the logical relationship among the layers, and only a few needed some explanation to understand the phase's connectivity. Furthermore, questions 11 and 12 presented the implication rate of the proposed model.

VIII. THREATS TO VALIDITY

To acquire the validation results from suitable and well-experienced industrial experts, we used a questionnaire-based survey method. A significant constraint found in this technique is that various research studies have uncovered that the emotional inclinations or subjective biases of respondents contrarily influence the study results. So there may be a few prospects of emotional predispositions and biases while responding to multiple questionnaire-based surveys. This threat was overwhelmed by the restricted and brief questions posed in the questionnaire. In this research work, the expert's responses were recorded about the proposed conceptual model dependent on the work or work area of the experts in offshore software development. However, there may be a threat that their respective work roles may have influenced the validation of the proposed conceptual model because of the understandability and ramifications of the RCM interaction in their pertinent job roles. To lessen this threat, we chose the most reasonable specialists having the appropriate job or roles in GSD. We avoided the specialists who had other numerous jobs including business analysts, technical support groups, and software testing teams, and so on.

TABLE 2. Results of the validation process based on experts reviews about the proposed conceptual model.

No.	Questions	Percentage of results	Description
1	**Is the concept of Global Software Development (GSD) understood?**	1. Clearly understood (100%) 2. Partially understood (0%) 3. Not understood (0%)	The recorded results showed that all eight experts had no issues in understanding the global software development phenomena. As there were only those experts selected that knew the GSD very well, along with good experience in distributed software development. Furthermore, we clearly described the GSD process in the questionnaire to overcome the challenges related to multiple terminologies.
2.	**Are you working in an organization/ Company/ Business Firm etc.? "Or" Do you work individually (Freelancing)?**	1. Organization/ Company/ Business firm (88%) 2. Individual (freelancing) (12%) 3. Other (0%)	The survey's results revealed that seven of the respondents were employees in an organization/ Company or a business firm, while only one of the eight respondents worked individually as a freelancer. None of the respondents were reported other than employees and freelancers.
3.	**What is your educational background?**	1. Software Engineering (50%) 2. Computer Science (38%) 3. Information Technology (12%) 4. Artificial Intelligence (0%) 5. Other Discipline (0%)	The selected experts had a diverse educational background. People with a Software Engineering background were four and Computer Science was counted as three along with one expert having Information and Technology Background. At the same time, none of the other experts having any other educational backgrounds were reported.
4.	**Do you agree that communication and coordination are the major challenges while managing the requirements change management in GSD?**	1. Yes (88%) 2. Partially (12%) 3. No (0%)	Seven of the eight experts have agreed upon the communication and coordination to be the major challenges while managing the new requirements changes by the offshore located software developers and project managers. In contrast, only one expert had partially agreed upon the communication and coordination to be the substantial challenges. It is worth mentioning that no expert agreed upon the ancillary of the communication and coordination challenges.
5	**Is the text readable in the proposed conceptual model?**	1. Yes (100%) 2. Partially (0%) 3. No (0%)	The conceptual model was presented along with an additional link for presenting the high-resolution image of the conceptual model as mentioned in the survey questionnaire (Appendix A). It was discovered that the experts had faced no problem reading and understand the conceptual model.
6	**Evaluation of the design of the proposed conceptual model.**	1. Excellent (25%) 2. Good (63%) 3. Average (12%) 4. Poor 5. Very Poor	Two of the experts considered the design of the proposed conceptual model to be excellent, along with five experts who considered the design to be good. In contrast, only one expert believed that the proposed design is average.
7	**Is the proposed conceptual model easy to understand?**	1. Easy to understand (50%) 2. Need some explanation (37%) 3. Need Detailed Explanation (13%)	In terms of the understandability of the conceptual model, we presented a comprehensive model to mitigate all the possible challenges more efficiently. Hence, based on this fact, four of the experts had no problem while understanding the working and sequence of the proposed model. Two experts believed that the proposed model should have some additional information to understand the overall model. However, one of the experts unveiled that there must be detailed information added in the model to better understand the proposed model.
8	**Do all the phases in the model contain relevant information?**	1. All are relevant (87%) 2. Some are relevant (13%) 3. None are relevant (0%)	Based on the collected and analyzed results, seven experts agreed that all the 3 phases in the proposed conceptual model contain the relevant information. In contrast, one of the experts believed that only some phases contained the relevant information. However, none of the experts believed that the information presented in the three phases contained any irrelevant information.

TABLE 2. ***(Continued.)*** **Results of the validation process based on experts reviews about the proposed conceptual model.**

9	**Is the relationship among the phases logical?**	1. All are logical (87%) 2. Some are logical (13%) 3. None are logical (0%)	In the proposed challenge-solution-based conceptual model, three major phases were linked in a sequence: identification of challenges, mitigation of challenges, and the implementation of the new requirements at distributed locations. After analyzing the obtained results, we found that some of the experts have found that some phases have a logical relationship; seven of the experts believed that all the mentioned phases are in a logical relationship. However, none of the experts believed that the relationship between phases is illogical.
10	**Are the challenges and solutions correctly and comprehensively identified in this model?**	1. All are correct and well defined (87%) 2. Some are correct and well defined (13%) 3. None are correct and well defined (0%)	The highlighted challenges and possible solutions were comprehensively identified through a rigorous literature review of the 27 SLR studies. Based on the experts' review, it was discovered that seven of the experts had firmly believed that all the possible challenges and solutions are correctly and well defined in the model while only one expert believed that some challenges and solutions are correct and well defined; however, none had mentioned that there were any incorrect or not well-defined challenges and solutions.
11	**Does this model help the offshore stakeholders to minimize the challenges?**	1. Yes (87%) 2. Partially (13%) 3. No (0%)	The major objective of this research work was to design efficient and robust challenges and mitigation practices based model for the practitioners (Software Developers) working in the domain of global software development or globally distributed software development to effectively manage and conserve the valuable resources. The validation revealed that seven experts have firmly believed that the proposed model is quite useful to reduce the communication and coordination challenges faced during the RCM in GSD. One of the experts has partially agreed on the usability of this proposed conceptual model. However, luckily, no expert disagreed about the practical implication of the proposed model.
12	**Do you think this model is feasible to be used to reduce the challenges?**	1. Yes (75%) 2. Partially (25%) 3. No (0%)	Based on the challenges faced by the offshore software development teams, the proposed model focused on the 107 mitigation practices that were incorporated in this model. We believed that this model is suitable enough to facilitate the offshore software development teams. Based on the expert's review, six of the experts agreed to reduce the challenges through our proposed conceptual model. In addition, two of the experts have partially agreed upon reducing possible challenges via the application of this model. However, none of the experts believed that this model is not useful to reduce the possible challenges.

The proposed conceptual model is purely based on the challenges and solutions-based results. So, there might be a chance that multiple challenges and solutions might have been missed which may affect the results or outcomes of the proposed conceptual model when implemented in software development organizations. This threat was overcome to some extent by seeking the responses from multiple experts as question 10 in table 2 highlighted the responses against the respective threat. As 13% of the participants did not agree upon the correct identification of challenges and mitigation practices. While 87% of the experts agreed upon the correct identification of challenges and mitigation practices.

The proposed conceptual model is not designed for industrial-based use only but it is also of greater importance for novice academic researchers. The validation results from academic experts are also of greater importance. Hence based on this argument, the lack of validation of the proposed conceptual model by the academic experts also poses a potential validity threat. This threat will be addressed in future work as the proposed conceptual model will be validated by multiple academic experts and researchers to enhance the validation results. Furthermore, based on the collected feedback from the industry-based experts, the proposed conceptual model was very complex to understand for some experts due to multiple challenges (75) and mitigation practices (107) included in the proposed model. However, the abstract version of the proposed conceptual model which was designed based on the feedback from the experts reduces the understandability of the proposed methodology by providing the abstract version of the conceptual model.

IX. RESEARCH IMPLICATIONS

The conceptual model proposed in this research work contained the commonly and rarely faced communication and coordination challenges and seven major sequential steps to help the multiple stakeholders and software industry-based practitioners to manage the important resources before the initiation and or implementation of the RCM process globally.

One of the important research implications is that necessary tools and technologies supporting communication and coordination issues need to be benchmarked as standards. Thereby, it would help in optimally utilizing the development resources during RCM in the GSD context. The predefined standards and protocols for managing the requirement change and communication and coordination are imperative for the project's success. Hence, the communication tools and practices highlighted in this research can help the offshore stakeholders to promptly manage the important tools and techniques before outsourcing a software project.

The proposed conceptual model has been presented in such a comprehensive way that it would help the novice academic researchers to understand the communication and coordination process and multiple challenges faced in this process and how to reduce these challenges to further enhance the upcoming research work related to the depreciation of multiple challenges in GSD domain. In addition, multiple aspects of the RCM process in GSD need to be improved including managing information transfer among multiple stakeholders. The proposed conceptual model addressed the major communication challenges that are key causes of the rise of improper information transfer among the stakeholders.

X. CONCLUSION AND FUTURE WORK

In this study, we proposed a conceptual model to improve the communication and coordination challenges faced during the offshore software development process. Multiple limitations in the existing conceptual or theoretical models and frameworks were analyzed based on which the proposed conceptual model was designed, while after the analysis process, it was discovered that no conceptual model or theoretical has focused on the improvement of the communication and coordination challenges faced during the RCM process in GSD. Thus to facilitate the software practitioners and academic researchers the proposed conceptual model was validated by the industrial experts and the results were recorded and presented in this research work.

The major aims of this research study were to:

1) Reduce the complexities in the communication and coordination process during RCM in Global Software Development (GSD).
2) Conserve the valuable software development resources and rework on new client's requirements.
3) Effective utilization of time, cost, and human resources to produce beneficial outcomes.
4) Enhance the knowledge of GSD practitioners to efficiently understand the known and unknown challenges and mitigation practices.
5) Improvement in the collaboration process while managing the requirement-based management activities.

The validation results showed that 87% of the experts have completely agreed upon reducing the communication and coordination challenges via this proposed model, and 75% of the experts have agreed upon the practical usability of this model to reduce the challenges. In comparison, only 25% of experts have partially agreed upon the usability of this model in software development organizations. Furthermore, based on the validation results, it is firmly believed that the proposed conceptual model in this study will effectively mitigate the commonly and rarely faced communication and coordination challenges during the RCM process in GSD after the practical application of the model in software development organizations.

As future work, we will test the results of the proposed conceptual model by applying it to some software development organizations in Pakistan to evaluate the usability of the proposed model. According to this research, no proposed model has been fully utilized on an industrial scale to mitigate the challenges. Currently, most software development organizations still rely on the commonly used practices for communication and coordination among multiple teams rather than using new solutions due to the complexity of new tools and technology and cost increments. In the future, we will get this model validated by academic experts to record their views and suggestions about our proposed model. The results of both, i.e. industrial and academic experts, will be compared and presented in another research study. It will be validated via different statistical tests to determine the difference between both and to identify the differences between academia and the practices currently performed in the software development industry. Besides, multiple Software development organizations still face different communication and coordination challenges due to limited cost, time, and human resources. There is also a need to identify and assess the reasons why different software organizations locally and globally lack in using modern solutions to reduce communication and coordination challenges. The major factors are to be identified, and the most optimal solutions will be presented in further research work.

APPENDIX A

The link to the questionnaire-based survey is mentioned below. The following questionnaire was distributed among the eight industrial experts.

https://docs.google.com/forms/d/e/1FAIpQLSezn7jJ71QHFbvCI23jJvyag6fAc2o5bwvXW7Tl6AsaRF60Dg/viewform?usp=pp_url

APPENDIX B

To provide more enhanced readability to the readers, the link to access the full resolution of the Figure of the detailed proposed conceptual model is mentioned below.

https://drive.google.com/file/d/1_VNfZbQyuDEyYxBaL3DIXtN0BntieiX0/view?usp=sharing

APPENDIX C

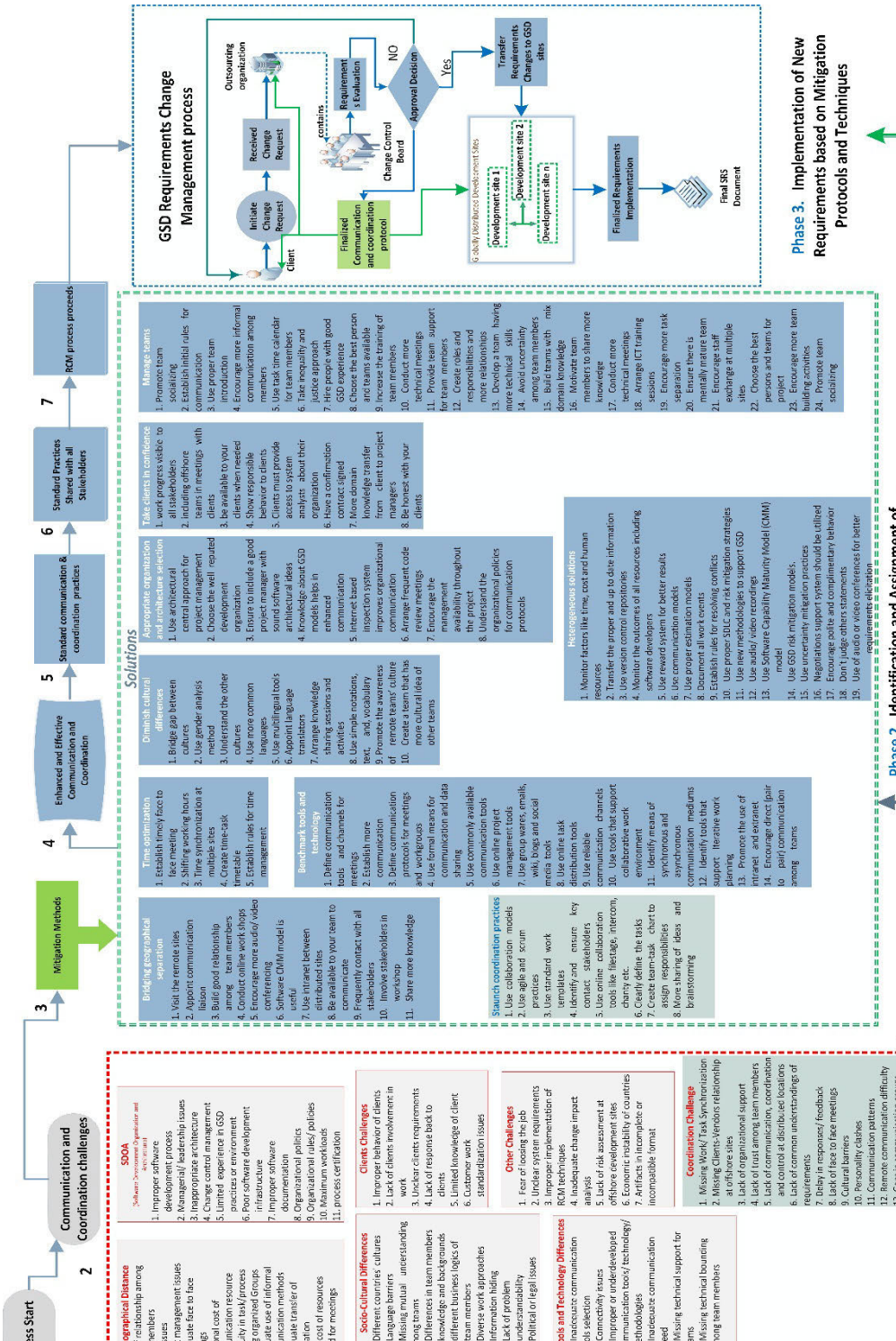

FIGURE 6. Detailed view of the proposed conceptual model.

ACKNOWLEDGMENT

The authors would like to acknowledge the support of Prince Sultan University for paying the Article Processing Charges (APC) of this publication. Furthermore, they also thank the Software Reliability Engineering Group (SREG) members at COMSATS University Islamabad (CUI) for their continued support and valuable feedback throughout this research work. They are thankful to the industrial experts who helped them by validating the usability and effectiveness of the proposed conceptual model.

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