CRUISE: A Platform for Crowdsourcing Requirements Elicitation and Evolution

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***Abstract*—Crowdsourcing has aroused a lot of interest in Requirements Engineering (RE) research community. RE activities are inherently complex in nature - both effort and time intensive, and quite dependent on each-other. The potential of crowdsourcing has been acknowledged for addressing complex tasks in general. We intend to study the potential of crowdsourcing for a broad spectrum of RE activities, i.e. from gathering requirements to their validation, through our proposed tool, CRUISE (Crowdsourcing for Requirements Engineering). CRUISE is aimed at involving interested users for gathering, analysing, validating, prioritizing, and negotiating requirements. In this paper, we present our vision and future roadmap for our proposed tool, CRUISE. We also report our observations from preliminary investigation experimental study to check the feasibility and viability of crowdsourcing based tool for Requirements Elicitation activity.**

***Index Terms*—Automated Requirements Engineering, Crowdsourcing, Participatory Requirements Engineering, Requirements Elicitation.**

I. INTRODUCTION

Requirements Engineering (RE) activities are not only intertwined but also complex in nature. The complexity associated with RE activities can be attributed to cognitive, socio-technical factors, linguistics [1], communication gaps [2], and lower involvement from business users [3]. Of these factors, any solution approach to have more involvement from business users can alleviate other problems as discussed in [1], [2], and [3]. Kujala et al. [4] have reported in their survey that user involvement has a statistical significant association with the success of project success; however, there is generally lack of customer or user involvement during early phases of RE. Bano and Zowghi [5] too have identified similar positive relationship between user involvement and project success in their systematic review study. Enhancing business users' participation during software development, especially during RE, to increase chances of successful project delivery remains a hard and challenging problem. Johann and Maalej [6] have recently conducted a study on how to push mass participation of users for RE by systematically delegating the responsibility for developing the requirements. They discuss the strengths as well as the risks associated with mass participation for RE in their study.

Agile development methodology is often perceived as a solution to address lower user involvement concern during early phases of RE. However, agile methodology has its own problems in terms of its associated risks and management challenges as reported in [7], [8]. Agile methodology, like conventional development methodologies, runs the risks of lack of consensus among customers and neglecting non-functional requirements. Therefore, there has been interest in RE research community to find possible solution approaches to increase customers or business users involvement during RE. Crowdsourcing approach can possibly meet the challenge of involving business users during requirements elicitation, analysis, prioritizing and negotiation.

Crowdsourcing is a distributed problem solving based approach (web-based and online) and business model which harnesses the network of individuals for problem solving [9], [10]. While crowdsourcing has been successfully applied for problem solving in several domains, investigating the potential of crowdsourcing for RE is a relatively unexplored, new and emerging area. Recently, there has been some work on crowd-centric RE and configuring crowd-sourcing for requirements elicitation [11], [12]. However, there are several issues and challenges with crowdsourcing for RE as the corresponding tasks in RE need domain-specific knowledge and analysing skills. Nevertheless, literature review indicates that crowd-sourcing approach has proved viable in leveraging human intelligence with equally specialized tasks in natural language processing tasks [13], [14] etc. Motivated by the feasibility of crowdsourcing approach to specialized tasks involving crowd contribution, we have explored the applicability of crowdsourcing to one of the RE activities, *requirements elicitation* in this paper. The specific research objectives of the study presented here can be summarized in following points:

1. RO1: To design and develop a crowdsourcing based requirements elicitation platform. The platform design and development includes building a website and implementing processes and structure which should guide the platform users to participate and complete their respective tasks effectively and efficiently.
2. RO2: To investigate the effectiveness of the proposed platform in-terms of the quality, completeness, and coverage of the elicited requirements.

3. RO3: To compare and contrast the proposed crowdsourcing based platform with traditional approaches and discuss the limitations of the proposed approach and future research directions.

The rest of the paper is organized as: Section-II presents a brief overview of the related work done where crowdsourcing has been leveraged for RE followed by our research contributions. In Section III, we discuss architectural design, features and design rationale of our proposed tool, CRUISE. Section IV presents the experimental study conducted with CRUISE, and the insights from the study. In section V, we summarize lessons learnt from the experimental study and our future work.

II. Background and Related Work

Requirements elicitation involves extracting and gathering the customers' expectations for the envisioned software system. This activity is inherently complex and challenging as there are multiple stakeholders of the system, each having different opinions on requirements, and identifying the right sources as well as gathering correct information is non-trivial. Traditional proposed solutions towards gathering requirements advocate having interviews, joint meetings or workshops, and onsite observations in order to make users involved and elicit requirements from them [15]. However, business users tend to see these exercises of gathering requirements as an intruder to their daily job routine. Elicitation of consistent and complete requirements requires effective communication and collaboration between the requirements engineers and the stakeholders. Crowdsourcing approach offers seemingly feasible solution for large-scale user-involvement that needs to be supported with carefully developed algorithms to filter appropriate requirements, and resolve conflicts among the contradictory requirements.

Crowdsourcing is an emerging online, distributed problem solving approach that addresses the problem through the involvement of crowd. Crowdsourcing-based solution approaches have been used in software engineering context too, however, for only a few software development activities as reported in the survey by Mao et al. [16]. Their survey indicates few instances where crowdsourcing has been used for requirements acquisition [17], [18] and categorization [19]. Breaux and Schaub [17] have explored crowdsourcing for extracting privacy requirements from privacy policies. Their study reveals increased requirements coverage as compared to manual extraction by trained experts.

Sutcliffe and Sawyer [20] recommend social collaboration for facilitating categorization and prioritization of requirements for product lines. Muganda et al. [21] advocate group-thinking for prioritizing and refining the requirements. Lim et al. [22] have explored the potential of crowdsourcing for stakeholder analysis. Lim and Finkelstein [23] suggest using social networks for large-scale requirements elicitation. Adepetu et al. [24] have proposed an outline of a platform to support RE activities in general using crowdsourcing, CrowdREquire. Snijder et al. [25] suggest Crowd-Centric Requirements Engineering (CCRE), and through a prototype of CCRE, *Refine*, they demonstrate that CCRE can provide engaged stakeholders and valuable interaction among those stakeholders. Such recommendations and suggestions have formed the basis of *Requirements Bazaar* [26] tool for community-driven innovation in RE activities. Requirements Bazaar tool, developed by Renzel et al. [26], aims at requirements elicitation and prioritization of requirements.

The existing related work and the literature review of recommendations to use crowdsourcing for RE have been the source of motivation and guidance for us to develop CRUISE. Our vision in developing CRUISE is more wide and comprehensive as compared to Requirements Bazaar tool. We intend to extend CRUISE beyond one activity of requirements elicitation in RE. The following section presents detailed overview of our proposed tool, CRUISE.

III. Proposed Tool: CRUISE

There has been a steep increase in number of crowdsourcing platforms coming up to support tasks in various domains including software engineering. Amazon Mechanical Turk (AMT[1]) is one such popular crowdsourcing tool. CrowdFlower[2] for data enrichment and mining, testbirds[3] for crowd testing, requirements bazaar[4] for gathering requirements are some of the examples of few existing crowdsourcing platforms to support different phases during software development. We studied the features of these tools and explored if any of these could be used for our study. Requirements bazaar tool was the closest to our need but its vision is limited to requirements gathering only. However, we had a vision of comprehensive crowdsourcing-based requirements tool, and therefore we decided to develop tool on our own. In this section, we present our strategy towards addressing our first research objective, RO1 that concerns with design and development of CRUISE.

There are several challenges in developing such a tool for RE where RE has its own challenges. The authors of the paper conducted several brainstorming sessions for finalizing design of the tool. Few of the design challenges that we had include: (i) should guest users be able to contribute to projects or only registered users have the permission to contribute; (ii) should the registration be controlled or any user can register and go ahead with contributing to projects; (iii) who holds the ownership of the project; (iv) what should be various roles associated with users; (v) should requirements gathering be itself broken to some subtasks, i.e. should the users be given with guided questions; (vi) how and when a requirement can be marked as finalized to be promoted to development. Literature review as discussed in section II guided us in formalizing our design decisions, briefly summarized in following points:

A. Guest v/s Registered Users

The underlying premise of crowdsourcing is to allow any user to contribute to the task either as a registered user or guest user. However, it is difficult to assess the motivation and interest level of users accessing crowdsourcing platform. For specialized

[1] https://www.mturk.com/mturk/welcome

[2] https://www.crowdflower.com/

[3] https://www.testbirds.com/

[4] https://requirements-bazaar.org/

tasks like RE, crowd formation and crowd control are two important aspects as indicated in the survey observations of Snijders et al. [25]. Their recommendation is to have interested sub-communities focusing on requirements, and to have moderators facilitate discussions (not let the crowd do so). Similar such recommendations have been proposed by Johann and Maalej [6]. They point out that as it is already difficult to negotiate requirements with a small group of stakeholders, so conflicts will rather become a norm than exception with heterogeneous group of users in a crowdsourcing based platform for RE. Therefore, some degree of control is required with crowd formation and moderation while developing such a platform. We have incorporated these recommendations in CRUISE by having a control at the time of user registration only. Only those users who get an invite from the project owners or from the admin users of CRUISE can register. Then, they can browse the projects, express their willingness to contribute to some project, and start contributing to projects.

We have not restricted formation of project's moderation group at tool level, leaving this decision to project owner as he may like to continue as moderator, or he may like to choose a moderator group. However, having a moderator for the project will be a guideline included in the instructions to use the tool.

B. Project Ownership and Access Control

Another design decision that we confronted with: should the user, who has created the project be the sole owner of the project, i.e. should that user only have the right to modify, archive, delete the project or should these privileges be extended to project contributors. Another related question was: should project's maintenance (archiving or deletion) be accessible to admin users. We decided to let contributors only view the project details. However, they can add modules as well to the project. Moderators can decide later whether that module should be a part of the project or not.

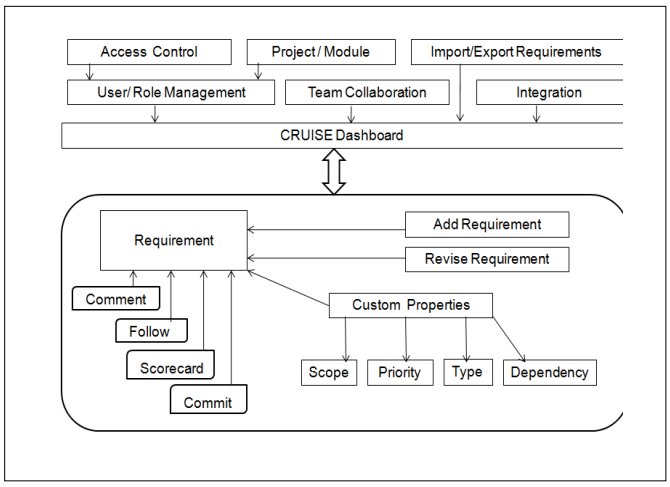

Fig. 1.Schematic Diagram of CRUISE

CRUISE allows the users, who have created the project, to modify, archive, and delete the project (Fig. 2 in appendix indicates how different project-lists are presented to a logged-in user in his dashboard). The privilege to archive or delete a project also lies with the CRUISE administrators so that the projects that have not been accessed for long and are lying idle may be removed to avoid any cluttering of projects in CRUISE database.

C. Requirements Identification

In addition to project and the users' access control, another important point that needs special consideration is that of identifying requirements and creating tasks for them. This aspect posed the challenges relevant to RE as well as to crowdsourcing. There is no precise definition of an atomic requirement in literature; therefore, it is difficult to allow creation of tasks to add any specific type of requirement. If the project owner himself adds requirements and seeks feedback either in terms of scores or comments, then the purpose of the tool is defeated [25]. These deliberations led to the decision of having flexibility in terms of task creation at the end of project owner. He may choose to gather requirements from crowd and seek scores for requirements in terms of likes, comments, follow-ups, and priorities of requirements. With the help of moderation group, the project owner may finalize the requirements statement and its priority. He may further seek opinion on this finalized requirements statement. We believe that such flexibility is required, and therefore, we have designed and developed CRUISE accordingly.

The schematic diagram of CRUISE, presented in Fig. 1, vividly depicts our design decision as discussed above. There are separate modules for managing users and their roles. Similarly, there is a different module for project management. Any user logging in to CRUISE first gets to view his/her dashboard where the projects owned by the user, projects to which user is contributing, and other projects in CRUISE are listed. From dashboard, the user can browse to selected project, its modules and their respective requirements. Each requirements statement has a scope, priority, dependency and type associated to it. The contributing users can follow, score and comment on the requirements. The moderators only can commit a requirement, i.e. can finalize a requirement to be promoted for design and development.

Based on the schematic diagram, as illustrated in Fig. 1, we have developed version 1.0 of CRUISE. The current version has implemented two attributes of the requirement – scope and priority. Additionally, this version supports commenting and scoring the requirement. The rest of the attributes of requirements, following and committing the requirement are currently under development. Before going ahead with the development of next version of CRUISE, we have carried out a preliminary investigation of our tool to check if its usage indeed offers some benefits to requirements elicitation, and also to check if the tool is able to do crowd control or not. The study has also helped us in discovering any mistakes or problems with the current version of CRUISE. Following section presents the details of our experimental study.

IV. EXPERIMENTAL STUDY

The potential of crowdsourcing in context of RE has been discussed by several authors as presented in Section II. But, most of such discussions are visionary ideas only. It is very important to validate the proposed vision through some experimental study. We have carried out proof-of-concept study to assess the

applicability of crowdsourcing approach to RE in terms of our research objectives, RO2 and RO3. In order to have a comparative study to address RO3, we decided to carry out our experimental study with undergraduate students who are currently doing a course in Software Engineering (SE). Doing a formal comparative study in an industry set-up is little difficult as the development team is pre-occupied with their daily tasks and getting them involved in validating the requirements is hard. Moreover, this is our first step towards validating first version of CRUISE. We believe it would be better to test a mature version of CRUISE in an industry set-up. Nevertheless, such a preliminary investigation would give us useful insights for further improving and developing CRUISE. This validation study will focus on feasibility of using CRUISE for carrying out requirements elicitation and prioritization.

We foresee some challenging problems in this study. A major challenge is to make participants understand the importance of RE, incentivizing the participants, and also making the participants realize our intent with the experimental study. Another difficult and challenging aspect of this study is validating the requirements collected through CRUISE against the requirements stated in requirements specification document of the system to be developed. Our choice of working with the group of students picked up for the study turned out to be of help in addressing this challenge. We were able to incentivize the students and keep them motivated in the study through a small percentage of marks in their SE course project grades.

We worked closely with the student participants' course advisor in order to carry out a meaningful and useful study. When the participants had covered RE in their lectures, and were ready to work on the same phase in their SE course projects, we identified two groups working on same project with the help of their course advisor. One of the groups, thus, was in the role of control group while the other one formed the hypothesis group in our study. We hypothesized that requirements collected through CRUISE are almost similar (at least 90% similarity) to the one collected through traditional requirements elicitation techniques. The choice of the project required a careful decision as the participants of the study need to have some familiarity with the system that they are supposed to work on. This would allow them to contribute for a carefully chosen project while participating in CRUISE study. The course advisor assigned project titled – '*Automate students' registration process at the onset of the semester*' to both of these groups.

The control group has 5 members, and the hypothesis group has 6 members. The control group is supposed to collect requirements by interviewing the Dean and the program office that is responsible for registering students at the beginning of semester through a manual process of form filling and approvals. The hypothesis group is supposed to work as moderator for the '*registration*' project created in CRUISE. Another group of 18 students (other than the control and the hypothesis group), expressing their intent to participate in the study, formed the crowd for the '*registration*' project in CRUISE. Though the number of participants may seem far lower than what one would expect for a crowdsourcing based study but we were able to get some good insights through this study. Secondly, our design of CRUISE is such that only interested participants who have been granted access to CRUISE will be able to contribute to project. Therefore, we do not expect a very large crowd practically to be a part of the project in CRUISE.

Having formed the groups required for study, and having decided the project to work with, we conducted our first meeting with the hypothesis group and the crowd. The meeting was aimed at explaining the idea of crowdsourcing, its application to RE, introduction to CRUISE, and the objective of our study. The meeting was followed by four more sessions with both of these groups where each session lasted for about an hour. The first session was a mock study to confirm that the participants – crowd and hypothesis group, understand their roles well and carry out the tasks accordingly. Some guidelines were shared with the participants beforehand like the requirements statement should be a complete statement, and not just a phrase with ambiguous interpretation. Crowd is supposed to comment, and the hypothesis group should continue with useful discussion over the requirements through comments. By the end of this first (mock-up session), we were confident that the participants are ready for actual experimental study.

In the next two sessions, requirements for the '*registration*' project and comments posted on those requirements by both the crowd and the moderators were collected by the moderators, who then finalized the meaningful and correct requirements. A total of 25 requirements were collected through CRUISE, of which 8 requirements were misguiding or fake requirements. Though we had not expected misguiding requirements as we assumed crowd participants are interested in contributing to the project (and, the study in turn). Nevertheless, our study resulted in situation that would otherwise arise while working with crowd – some users are interested while some are cheaters. In parallel, the control group collected requirements for the same project using interview technique of requirements elicitation. They collected a total of 8 requirements from the Dean and the program office.

The requirements collection phase was then followed by comparative study of the requirements collected through the two different ways – traditional and using CRUISE. The control group, the hypothesis group, the crowd and the stakeholders of this project – the course advisor, the Dean and a representative from program office participated in this *last session* of our study. Of the 25 requirements gathered using CRUISE, 8 have been identified as fake requirements by the hypothesis group. These particular requirements statements had no meaningful complete phrase or statement to them. These were actually meaningless collection of words. Discarding these, 17 requirements are assumed to be correct by the hypothesis group.

The participants of the *last session* started analyzing and comparing these 17 requirements against the requirements collected through interviews (8 in number). Since two different groups have collected the requirements and atomicity of a requirement is different to these different groups, so they carefully studied each and every requirements statement to find similarity and differences. The hypothesis group marked 2 requirements from CRUISE as fancy feature that should be dropped. These two requirements statements are:

1. Automated hostel-room selection choice should be available.
2. Room-mate selection feature should be there

These two requirements stemmed from the fact that first year students need to get hostel fee payment checked (i.e. all accounts' related things clearance), and few students wanted additional features in addition to hostel fee check. Since both of the above-mentioned requirements are out of scope of '*registration*' project, therefore, hypothesis group dropped these requirements after marking them as fancy features.

From the remaining 15 requirements, the analyzing group involved in comparative study found 9 requirements similar to 5 of the requirements elicited through interviews. The difference in numbers is because control group considered a group of 2-3 related statements as one requirement whereas the hypothesis group expressed requirements in terms of individual statements. For example: Login requirements in terms of validation, password and encryption of password were stated together as one requirement by the control group, whereas the hypothesis group segregated them as three different requirements at the time of requirements finalization. Following statements, as collected by the respective groups, vividly bring out the point of difference in atomicity of requirements:

1. Login requirements from Control group:

"This is our first step where student will prove his authenticity and initiate the process by entering his username and password. When student will enter his details system will look up for that data entry in the student information system, if a match is found student can proceed else he will be reported with an error message in which he case."

2. Login Requirements from Hypothesis group:

Similar login requirements came from hypothesis group, however, in the form of separate three requirements as stated below:

i) Log in credentials (Student's mail-id to serve as his user id to login to registration application and new students can use a unique id to login which is given to them at the time of admission.).

ii) User Id for login valid and present in the college records.

iii) Password will be set by the students themselves. The format of the password will be - at least 8 Characters with at least one uppercase letter, and at least one special character. The password should match the respective login id to allow a successful login.

The above requirements statements clearly bring out the reason of the difference in the counts of the requirements collected by the control group and the hypothesis group. From these statements from the collected requirements, one more point becomes evident – with the help of CRUISE tool, requirements collected were elaborate in nature. This can be attributed to the fact that an individual contributing to a project as part of the crowd tends to write his requirement (his idea for a feature to be incorporated in detail) eloquently. The 'login' requirements collected by hypothesis group evidently illustrate this benefit of using a crowdsourcing-based tool for RE. A summary of comparison of the requirements collected by the two groups respectively is presented in Table 1 below:

TABLE I. CRUISE AND INTERVIEWS REQUIREMENTS COMPARISON

Total Requirements in CRUISE	**Requirements Count**		
	Both in CRUISE and interviews data	***Through Cruise only***	***Through interviews only***
15	9	2	3

This study is intended to analyze not only the number of requirements identified through manual reviews and through our tool but also the quality of the elicited requirements and the time taken to prioritize the requirements manually against the time taken to carry these tasks through tool. Such a quantified comparative study will be of help in concluding benefits as well as drawbacks of using crowdsourcing for RE. We are of the view that there are qualitative measures too involved in such a comparative study like reduced conflicts and confusions, level of satisfaction with the requirements, quality of finalized requirements etc. Though it is difficult to quantify such qualitative measures, but gathering information on these measures through a well-laid out survey with participants can provide insight towards the potential of utilizing crowdsourcing for RE. We followed such a *qualitative study post quantitative analysis of collected requirements*. In terms of qualitative study, we had following observations:

1. The requirements gathered through CRUISE, and missed through interviews were about one module only - 'administrator', and the privileges of the user acting as administrator.
2. The requirements elicited during interviews but not found in CRUISE tool included categorization of registration application users as 'new' and 'old'. Another missed requirement through CRUISE was related to getting students' consent on a couple of forms for 'new' students (in addition to registration form).

The requirements, as mentioned in point 2 above, got missed through CRUISE can be attributed to the fact that the participants of the study are in their final years. They happened to forget the process of registration they had to go through for the first time. This validation study thus reveals that the requirements gathered through CRUISE platform are at least as good as collected through interviews. There was a miss of one (business) aspect but at the same time, there was a value addition in terms of 'system administrator' role and his privileges. These observations answer RO2 and RO3 as – with a careful crowd formation, crowd control and moderation, one can expect the quality of requirements gathered using crowdsourcing approach as good as elicited through traditional methods of requirements gathering.

Though qualitative approaches towards research studies are criticized for being influenced or biased by the participants and by those who are conducting such studies but it has been argued

by Host et al. (2005) and Wohlin et al. (2003) that exploratory and empirical methods are crucial for a discipline like SE where variables to study are either not known or partially known. We have followed their recommendations in our experimental study for validating CRUISE platform's potential so as to mitigate any risks to validity of our study. We conducted pre-study session as a mock-up session for the actual study to be conducted. The groups were formed randomly without any bias or preference.

V. Future Work

In this paper, we have presented CRUISE as a platform for studying the potential of crowdsourcing in carrying out various activities in RE. There are a number of crowdsourcing platforms available for crowdsourcing but most of those are not relevant to RE. Our contribution lies in developing a crowdsourcing platform, CRUISE platform with a vision towards realizing the potential of this platform for various activities of RE. We have also presented an experimental study with our proposed tool. The presented study is a preliminary investigation towards validating CRUISE, and verifying if meaningful and useful requirements can be elicited using crowdsourcing.

The development of such a visionary tool and conducting studies to validate the same are not without challenges. In order to realize our vision of CRUISE, we brainstormed a lot to carefully analyze design decisions. We also decided to proceed with stepwise development, testing and validation of CRUISE to ensure that our tool development is in line with our vision. This initial phase of taking design and development decisions was both challenging and time-consuming. After developing the first version of CRUISE and conducting validation study, we found that the effort spent in planning the tool as well as the preliminary study are of help to mitigate the associated challenges and risks.

The validation study presented in this paper may run the risk of subjectivity, possibly misinterpreting the requirements or incorrect mapping of requirements between the control group and the hypothesis group. These risks were identified during the course of the study, and were mitigated through group discussions to ensure a fair study. Our validation study with CRUISE reveals that crowdsourcing could be successfully used for RE, however crowd formation needs special attention from the project owners and moderators. The role of moderators is very important in facilitating the discussions over requirements and finalizing the requirements to be developed. This responsibility cannot be left to the crowd alone.

The observations from the study presented in this paper are quite encouraging for us to continue with further enrichment of CRUISE. We further plan to incorporate the identified and planned features that are not part of the current. Next, we intend to perform validation study in context of other activities of RE. We also plan to perform such studies in future in an industry setup with small-scale as well as large-scale projects to check the practical applicability and scalability of our proposed tool, CRUISE. The potential and practical applicability of crowdsourcing for RE have been acknowledged and claimed in earlier works. We believe that through validation studies on our proposed tool, CRUISE, we shall be able to support such claims with quantified observations, and that our future experimental studies will help in recommending useful guidelines to minimize the challenges and risks associated with using crowdsourcing for RE.

References

[1] B. Nuseibeh and S. Easterbrook, "Requirements Engineering: A Roadmap," in proceedings of the conference on The Future of Software Engineering, 2000, Ireland, pp. 35-46.

[2] L. Karlsson, A.G. Dahlstedt, B. Regnell, J.N. Dag and A. Persson, "Requirements engineering challenges in market-driven software development – An interview study with practitioners," in Information and Software Technology, vol. 49, 2007, pp. 588-604.

[3] J.M. Bhat, M. Gupta and S.M. Murthy, "Overcoming Requirements Engineering challenges: Lessons from offshore outsourcing," IEEE Software, 2006, pp. 38–44.

[4] S. Kujala, M. Kauppinen, L. Lehtola and T. Kojo, "The Role of User Involvement in Requirements Quality and Project Success," in proceedings of 13th IEEE International Conference on Requirements Engineering, 2005, pp. 75-84.

[5] M. Bano and D. Zowghi, "A systematic review on the relationship between user involvement and system success. Information and Software Technology," 2015, pp. 148–169.

[6] T. Johann and W. Maalej, "Democratic Mass Participation of Users in Requirements Engineering?," in proceedings of IEEE 23rd Requirements Engineering conference, 2015, pp. 256-261.

[7] B. Ramesh, L. Cao and R. Baskerville, "Agile requirements engineering practices and challenges: an empirical study," in Information Systems Journal, Wiley & Sons ltd., vol. 20, no. 5, 2007, pp. 449-480.

[8] B. Boehm and R. Turner, "Management Challenges to Implementing Agile Processes in Traditional Development Organizations," IEEE Software, 2005, pp. 30-39.

[9] D. C. Brabham, "Crowdsourcing as a model for problem solving an introduction and cases," in Convergence: the international journal of research into new media technologies, vol. 14, no. 1, 2008, pp. 75–90.

[10] J. Howe, "The rise of crowdsourcing," Wired Magazine, vol. 14, no. 6, 2006, pp. 1-4.

[11] R. Snijders, F. Dalpiaz, M. Hosseini, A. Shahri, and R. Ali, "Crowdcentric requirements engineering," in Proceedings of the 2014 IEEE/ACM 7th International Conference on Utility and Cloud Computing, 2014, pp. 614–615.

[12] M. Hosseini, K. Phalp, J. Taylor, and R. Ali, "Towards crowdsourcing for requirements engineering," in Joint Proceedings of REFSQ-2014 Workshops, Doctoral Symposium, Empirical Track, and Posters, 2014, pp. 82–101.

[13] R. Snow, B O'Connor, D. Jurafsky and A.Y. Ng, "Cheap and Fast – But is it Good? Evaluating Non-Expert Annotations for Natural Language Tasks," In proceedings of EMNLP – 2008, pp. 254-263

[14] P.-Y. Hsueh, P. Melville, V. Sindhwani, "Data Quality from Crowdsourcing: A Study of Annotation Selection Criteria," NAACL HLT Workshop on Active Learning for NLP, 2009, pp. 27–35.

[15] D. Zowghi and C. Coulin, "Requirements Elicitation: A Survey of Techniques, Approaches, and Tools," chapter in Engineering and Managing Software Requirements, A. Aurum and C. Wohlin (eds.), Springer Berlin Heidelberg, 2005, pp. 19–46.

[16] K. Mao, L. Capra, M. Harman and Y. Jia, "A survey of the use of Crowdsourcing in Software Engineering," Technical Report RN/15/01, Department of Computer Science, University College, London, 2015.

[17] T. Breaux and F. Schaub, "Scaling Requirements Extraction to the Crowd", in proceedings of 22nd IEEE International Conference on Requirements Engineering, 2014, pp. 163-172.

[18] M. Hosseini, A. Shahri, K. Phalp, J. Taylor, R. Ali, and F. Dalpiaz, "Configuring crowdsourcing for requirements elicitation," in proceedings of the 9th International Conference on Research Challenges in Information Science, 2015.

[19] P. Nascimento, R. Aguas, D. Schneider, and J. de Souza, "An approach to requirements categorization using Kano's model and crowds," in proceedings of the 16th IEEE International Conference on Computer Supported Cooperative Work in Design, May 2012, pp. 387–392.

[20] A. Sutcliffe and P. Sawyer, "Requirements Elicitation: towards the unknown unknowns," in proceedings of 21st IEEE International Conference on Requirements Engineering, 2013, pp. 92-104.

[21] N. Muganda, D. Asmelash, and S. Mlay, "Groupthink decision making deficiency in the requirements engineering process: Towards a crowdsourcing model," SSRN Electronic Journal, 2012.

[22] S. L. Lim, D. Quercia, and A. Finkelstein, "StakeSource: Harnessing the power of crowdsourcing and social networks in stakeholder analysis," in Proceedings of 32nd IEEE International Conference on Software Engineering, 2010, pp. 239–242.

[23] S. L. Lim and A. Finkelstein, "StakeRare: Using social networks and collaborative filtering for large-scale requirements elicitation," IEEE Transactions on Software Engineering, vol. 38, no. 3, 2012, pp. 707–735.

[24] A. Adepetu, K. A. Ahmed, Y.A Abd, A.A. Zaabi and D. Svetinovic, "CrowdREquire: A Requirements Engineering Crowdsourcing platform," In Wisdom of Crowd, AAAI Spring Symposium series, 2012.

[25] R. Snijders, A. Ozum, S. Brinkkemper and F.Dalpiaz, "Crowd-Centric Requirements Engineering: A method based on crowdsourcing and gamification", Masters Thesis, 2015, Department of Information and Computing Sciences, Utrecht University, Utrecht, The Netherlands.

[26] D. Renzel, M. Behrendt, R. Klamma and M. Jarke, "Requirements Bazaar: Social requirements engineering for community-driven innovation," in proceedings of 21st IEEE International Requirements Engineering Conference (RE), Rio de Janeiro, 2013, pp. 326-327.

[27] C. Wohlin, M. Host and K. Henningsson, "Empirical Research Methods in Software Engineering," Lecture Notes in Computer Science: Empirical Methods and Studies in Software Engineering: Experiences from ESERNET, Wang, A. I. and Conradi, R., Springer Verlag, 2003, pp. 7-23.

[28] M. Höst, C. Wohlin, and T. Thelin, "Experimental Context Classification: Incentives and Experience of Subjects," In Proceedings of IEEE International Conference on Software Engineering, 2005, pp. 470-478.

APPENDIX

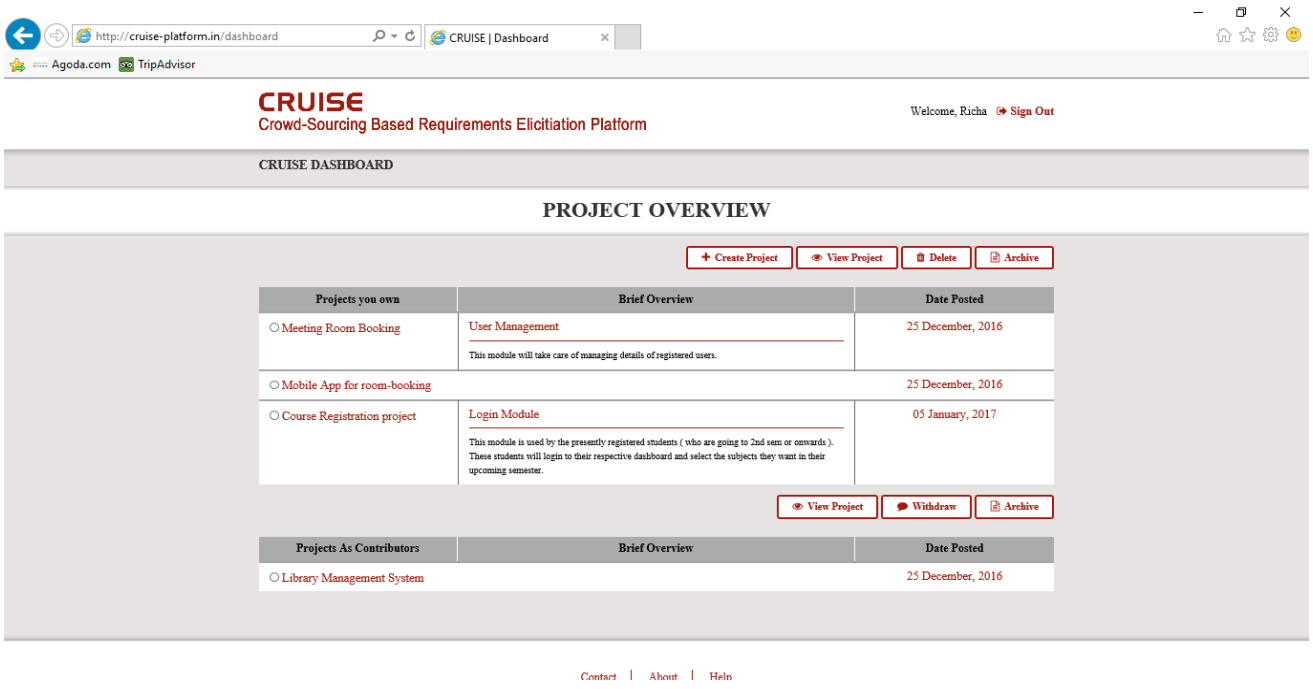

Fig. 2. Dashboard of a logged-in user - CRUISE