A Quality Control Model for the Crowdsourced Software Products

Z. Safdar[1], M. Qadir[2], M. M. M. Bagram[3], M. Alam[4], S. Farid[5]

[1]*Department of Information Technology, University of Sahiwal, Pakistan.*
[2,5]*Department of Computer Science, Bahauddin Zakariya University, Multan, Pakistan.*
[3]*Department of Business Administration, Allama Iqbal Open University, Islamabad, Pakistan.*
[4]*Informatics Complex, ICCC, H-8, Islamabad, Pakistan.*

[5]shahidfarid@bzu.edu.pk

Abstract- Crowdsourcing in general is an online distributed model for solving problems where the organizations use large number of contributions from Internet users for ideas and services towards problem solving. Crowdsourcing assists to divide work in tasks for contributors to achieve desired results and increase performance of platforms. Crowdsourcing embraces cheap labor that means less credible output and low quality products. Therefore, this study aims to propose a novel model in order to control the quality of the crowdsourced product. Exploratory mode of research has been adopted in order to explore the quality of crowdsourced software products. Furthermore, a roadmap is also formulated to lead crowdsource organizations in order to improve the quality of developed crowdsource product.

Keywords- Crowdsourcing, crowdsource platforms, quality of crowdsource product

I. INTRODUCTION

Crowdsourcing is an effective way for receiving contributions from large group of Internet users to generate ideas and solve problems [1-2]. Crowdsourcing is a mixture of two words "crowd" and "outsourcing". Crowd comprises of diverse Internet users that contribute to solve problems, whereas outsourcing remains famous for dividing work between workers although the work comes from predefined sources. However crowdsourcing includes work from distinct and undefined sources as shown in Fig. 1. Crowdsourcing has already been adopted in various fields like art, business, governance and medicine etc. Open source crowdsourcing platforms are available to provide significant help to crowd and aid crowd to become more active. Some of the popular crowdsourcing platforms include TopCoder, uTest, Mturk, Crowdx, Bountify, Pay4Bugs and AppStori [2-7].

Crowdsourcing organizations strive to increase their production but delivery of products without meeting the quality benchmarks is insufficient. Products quality is a subjective attribute as according to Joseph M. Juran "quality is fitness for use and customer defines fitness". Crowdsourcing embraces cheap labor that means less credible output and low quality products, as managing large scale workers has become difficult for requesters in crowdsourcing platforms [8].
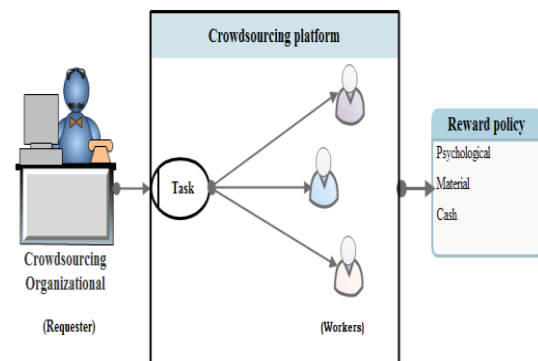

Fig. 1: Architectural overview of a typical crowdsourcing environment

Since workers are paid for their contribution often a cash incentive effect crowd workers to complete allowed tasks quickly rather than doing well. As crowdsourcing platforms allow many unqualified participants to work that result in large quantity of unusable data. Therefore, each task is completed multiple times that increase monetary costs as well as affects the quality of the output [9-15].

A quantitative study has been conducted by Hirth, Hoßfeld [16] that exploring the crowdsourcing workers per country conducting a survey. Results show that majority of workers belong to Indonesia and Bangladesh as shown in Fig. 2.
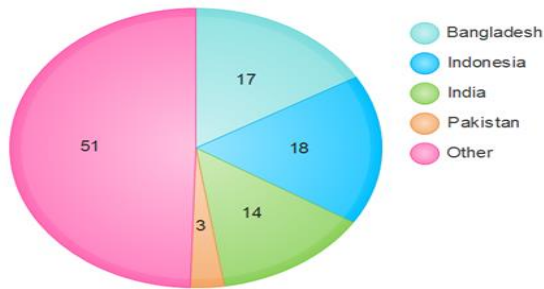
Fig. 2: Workers per Country [16]

In recent years, several studies deal with crowdsourcing platform but these are deficient to address quality aspects of delivered software products that still needs to be focused [10-15].

Therefore, this study intends to propose a quality control model in order to assure the quality of software products by conducting an exploratory study on the state of the art literature.

This study is worded as Section II presents extensive review of literature regarding the software products quality. Section III describes adopted research methodology. Section IV presents proposed quality model and Section V describes future work and concludes this study.

II. LITERATURE REVIEW

The term Crowdsourcing was coined by Jeff Howe [17-18] and can be defined as "a combination of two words crowd and outsourcing facilitating with a pool of cheap labor opinions and ideas for problem solving [17]. The crowdsourcing process embraces finding solution of problems from unidentified group of people where the owner of crowdsourcing task is called requester who submits the task on crowdsourcing platform with associated time duration and reward. The persons who work on the submitted task are called workers [1, 7, 19-20].

The workers provide best submission of task to earn reward. The requester collects all the submissions of workers and grant reward to corresponding workers for their contributions. Sometimes requester has to reward all workers who have completed the task according to the defined instructions [21]. Crowdsourcing platforms have been used to describe tasks and services through which they get contributions from diverse workers. Different crowd superior systems that are used for crowdsourcing include Amazon Mechanical Turk, TopCoder, eBay, StackOverflow, AppStori, uTest and CrowdFlower [22-24]. Some famous online crowdsourcing systems that are used for large scale gathering of human intelligence are shown in the Table 1 along with the services that they perform and categories of tasks that are accomplished by these systems [2-5]. Amazon MTurk was developed in 2005 to provide intermediary services for performing variety of tasks. Amazon MTurk is in general online workplace for crowd to add their contributions and get reward where requester submits the crowdsourcing task that is called Human Intelligence Tasks (HIT) as shown in Fig. 1 [25-26]. Amazon MTurk maintains the percentage of submitted task by workers. There is no mechanism for the fair evaluations of the tasks [27]. TopCoder is an online business model of crowdsourcing with the purpose of developing software products [23, 28]. StackOverflow is a web site in which users ask question and get response additionally they can also answer other questions [29] furthermore, voting is conducted for the checking the quality of questions and answers. StackOverflow does not include a mechanism for checking the unfair voting for workers. eBay is also an online system which cannot work without contributions of users that embrace seller and buyer relationship whereas sellers and buyers reputation is maintained [1, 17, 22].

Table 1: Crowdsourcing Organizations and their Services

Organization	Service	Tasks	Reference
Amazone Mechanical Turk	Intermediary	Variety of interesting tasks to be performed	[5-7]
Crowdx	Mobile network Monitoring	Collect millions of data samples	[30]
uTest	Software testing and feedback	Testing software	[4]
Topcoder	Development, Design	Application development, design and prototyping	[3, 28]
Bountify	Intermediary	Variety of tasks	[20]
Pay4Bugs	Software Testing	Tasks to find bugs	[31]

One of the wide-ranging goal of crowdsourcing is to develop high quality software products within scope, time and budget. Software quality is vital and crucial for the survival of the software product

as it has have already highlighted in the existing literature [6, 7, 9, 18, 22, 25, 28, 32-39]. Quality of a software product comprises of diverse attributes or characteristics including controllability,

portability, reliability, functionality, performance, efficiency, security, maintainability, usability and etc. [40-41]. Various identified studies of crowdsourcing have only discussed different task designing processes and issues regarding task designing and are deficient to facilitate by providing a mechanism or a process to enhance the quality crowdsourced software products. An effort has been made by [33] exploring five crowdsourcing websites in order to identify the quality assurance techniques that can help to improve the crowdsourced data. A survey has been conducted to discover the reliability of websites like YouTube etc. and highlight different factors that regulate the crowdsourcing data. Yang introduced the content based techniques for developers to enhance the performance of developers with respect to qualitative deliverables of software [28]. In addition to that Wu et al. worked on the crowdsourcing platforms such as TopCoder, provides individual as well as peer software development techniques and methodologies by proposing a model of theoretical game and it provides different strategies regarding behavioral analysis of contestants in TopCoder [42].

Main challenge in crowdsourcing is how to encourage workers to produce good output. Currently there is no appropriate way of guarantying quality in crowdsourcing products [10-15]. It has been urged by [43] increase in financial incentive doesn't increase quality but increase quantity. So there is need of a better approaches to ensure the quality. The key concerns for the development of software on crowdsourcing platforms defined in different studies includes task decomposition, coordination and communication, planning with scheduling, and knowledge and intellectual property [2]. However, few studies have been conducted to analyze the quality of crowdsourced software products. Diverse studies addresses existing quality control approaches used in crowdsourcing systems that include effective task preparation. There are techniques and approaches for defining task and making compensation policy but there is no model for assuring quality. Hence crowdsourcing companies need to think about some goals for the quality evaluation of software products. Therefore, this study contributes in a way by providing quality control model for crowdsourcing platforms to enhance the quality of crowdsourcing products.

III. Research Method

Exploratory research method has been adopted to explore current vision and state of the art literature intensively. Exploratory model is beneficial if the targeted issue has never been addressed or insufficient evidences are attainable and researcher intends to probe the research arena [44-45]. Moreover, an exploratory study initiates erecting observations and penetrating for a pattern. The researcher advance the idea about why this pattern arises. This approach is occasionally recognized as the inductive method. Therefore, exploratory research provides an appropriate way to assist researcher with the basic work for later studies [44, 46].We have adopted the exploratory method to identify the problem that has not been studied more intensively.

IV. Proposed Quality Model

A quality control model has been proposed to overcome problems experienced by the crowdsourcing organizations. Proposed model has been divided in different layers or blocks such as task initialization, quality control approaches incentive policies, etc. as shown in Fig. 3.

A. Crowdsourcing Organization:
First block is the crowdsourcing organization where requester submits the task on the crowdsourcing platform. Workers select the task they want to perform and after completion they resubmit work to the requester on the crowdsourcing platform. In result the requester pays the contributor for his working. Workers may not want to work on the task in exchange of the reward. In some cases workers face problems related to the task specification. In our proposed model we specify some rules that crowdsourcing organization may follow to achieve the desired quality of the products. Crowdsourcing organization must define the description of the task for the contributors to follow. Organization must define task allocated time in which worker will submit the completed task. At initial level requester will define quality criteria to the worker and on that bases agreement will be signed for incentives.

B. Workers Management:
Second block is workers management where organization should maintain the profile of the worker and keep track of the worker activities. Organization selects workers on the basis of defined criteria of the organization to select workers. Improper selection of workers for task reduces the quality of result. Breaking down task allows identifying quality assurance. Crowdsourcing task designed in proper way provide useful results. Workers that are selected on the base of the qualification, reputation based, knowledge based provide useful response. Training and workshops conducted for the workers improve their skills. Select the worker that fulfills the required criteria of organizational standards.
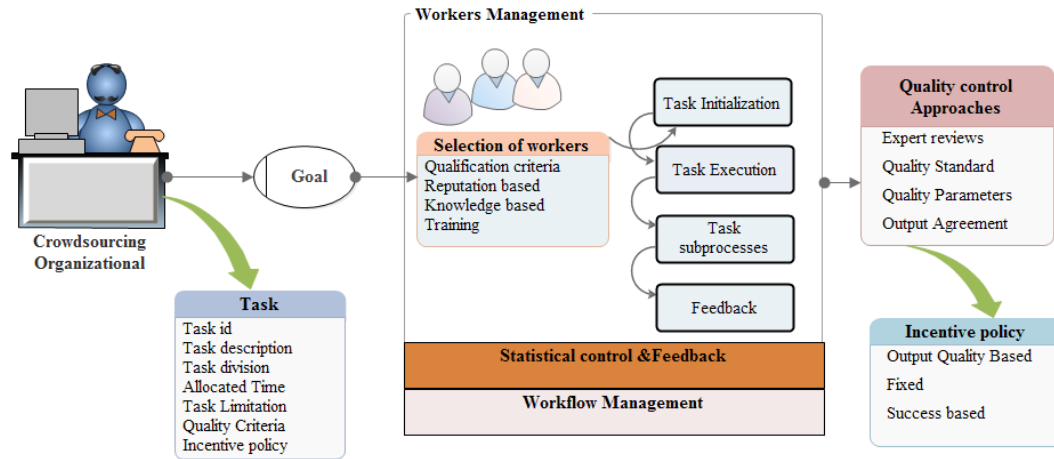
Fig. 3: A Quality Control Model for Crowdsourcing

C. Task Initialization:

The next block is namely task initialization. The difficulty of the tasks are intermediate in their difficultly, estimate crowd workers skills, their intentions and leveraging them for inferring true responses works well, even though with an additional computation cost. In proposed model crowdsourcing platform help workers to start working on the distributed task described by organization. Description of task helps organization to meet quality standards. Workers start working on task and get instructions from the organization. Maintain requester and worker interaction for performing tasks as specified.

D. Quality Control Approaches:

Next block is about quality control approaches that have not been adopted before. Expert reviews and quality standards are required to meet the quality of products for customer satisfaction. Quality control mechanisms should be adopted that crowdsourcing organization must follow for maintenance of product quality and reputation of the organization. Existing approaches can be classified into two types such as task design time and task run time. Both approaches are not mutually-exclusive. A task can be utilized both approaches to enhance the opportunity of attaining quality product. At task design time crowdsourcing requesters may force procedures for devising a well-designed chore processes and allows most suitable and professional crowd for contribution to that task. While these techniques enhance the chance of obtaining high quality contributions from the crowd, still it is required to check the quality of contributions at task run time. As experienced personnel might submit below quality contributions due to misinterpretation of task. This can be achieved by managing workflow from task design to task run time. Proposed model follow principles of workflow management and statistical control of

overall processes in crowdsourcing platform Therefore, requesters should enforce quality control mechanism approaches not only at the time of execution task but also during the collection of contributions from crowd and possibly combined to build the ultimate task answer.

E. Incentive Policy:

Incentive policy is the last block that must be trailed by organizations to motivate workers to develop products according to the quality standards described by the organization. Proposed model describe incentive policy should be followed by the quality control approaches. Resulted output should be verified by the experts and check if it meets quality standards and on quality based incentives should be given to the workers.

V. CONCLUSION AND FUTURE WORK

Crowdsourcing is an effective way for receiving contributions from large group of Internet users to generate ideas and solve problems. Without qualified crowd, crowdsourcing platforms remain unattractive for organizations as tasks are completed inaccurate and slowly, this effect the quality of products. As crowdsourcing allows any person to participate that sometimes result in large quantity of unusable contributions. Crowdsourcing organizations need to improve the quality of developed products. Therefore a quality model has been proposed to assure the quality of crowdsourced products by overcoming the problems experienced by the organizations endorse in crowdsourced development. Additionally the proposed model will help to maintain crowd and task design as well as maintaining quality standards for organizations. In future work we will contribute by providing quality control mechanisms that will assist crowdsourcing platforms to maintain their processes and quality of products.

Crowdsourcing is an elusive and subjective term; there are many issues and challenges related to quality of software products developed through crowdsourcing that require new quality control mechanisms. Subsequently, there should be some crowdsourcing principles to meet the goals of crowdsourcing platforms in rigid traditional systems. In future we need to identify issues and we need to plan the evaluation criteria. However, for future perspective we have highlighted some of most convincing issues for the further analysis to evaluate the current and new promising technological to enhance the quality of software products.

REFERENCES

[1] Allahbakhsh, M., et al., *Quality control in crowdsourcing systems.* IEEE Internet Comput, 2013. **17**(2): p. 76-81.

[2] Stol, K.-J. and B. Fitzgerald. *Two's company, three's a crowd: a case study of crowdsourcing software development.* in *Proceedings of the 36th International Conference on Software Engineering.* 2014. ACM.

[3] Kim, H., *E-learning Privacy and Security Requirements: Review.* Journal of Security Engineering, 2013. **10**(5): p. 591-600.

[4] Chen, Y. and W. He, *Security risks and protection in online learning: A survey.* The International Review of Research in Open and Distributed Learning, 2013. **14**(5).

[5] Baruque, L.B., C.B. Baruque, and R.N. Melo. *Towards a framework for corporate e-learning evaluation.* in *Proceedings of the 2007 Euro American conference on Telematics and information systems.* 2007. ACM.

[6] Moodley, F., J.-P. Van Belle, and N. Hasteer. *Crowdsourced software development: Exploring the motivational and inhibiting factors of the South African crowd.* in *Cloud Computing, Data Science & Engineering-Confluence, 2017 7th International Conference on.* 2017. IEEE.

[7] LaToza, T.D. and A. van der Hoek, *Crowdsourcing in software engineering: Models, motivations, and challenges.* IEEE software, 2016. **33**(1): p. 74-80.

[8] Huang, E., et al. *Toward automatic task design: a progress report.* in *Proceedings of the ACM SIGKDD workshop on human computation.* 2010. ACM.

[9] Van Exel, M., E. Dias, and S. Fruijtier. *The impact of crowdsourcing on spatial data quality indicators.* in *Proceedings of the 6th GIScience international conference on geographic information science.* 2010.

[10] Aker, A., et al. *Assessing Crowdsourcing Quality through Objective Tasks.* in *LREC.* 2012.

[11] Allahbakhsh, M., et al., *Quality control in crowdsourcing systems: Issues and directions.* IEEE Internet Computing, 2013. **17**(2): p. 76-81.

[12] He, Z., J. Cao, and X. Liu. *High quality participant recruitment in vehicle-based crowdsourcing using predictable mobility.* in *Computer Communications (INFOCOM), 2015 IEEE Conference on.* 2015. IEEE.

[13] Hsueh, P.-Y., P. Melville, and V. Sindhwani. *Data quality from crowdsourcing: a study of annotation selection criteria.* in *Proceedings of the NAACL HLT 2009 workshop on active learning for natural language processing.* 2009. Association for Computational Linguistics.

[14] Oleson, D., et al., *Programmatic Gold: Targeted and Scalable Quality Assurance in Crowdsourcing.* Human computation, 2011. **11**(11).

[15] Zaidan, O.F. and C. Callison-Burch. *Crowdsourcing translation: Professional quality from non-professionals.* in *Proceedings of the 49th Annual Meeting of the Association for Computational Linguistics: Human Language Technologies-Volume 1.* 2011. Association for Computational Linguistics.

[16] Hirth, M., T. Hoßfeld, and P. Tran-Gia, *Human cloud as emerging Internet application-anatomy of the microworkers crowdsourcing platform.* University of Wurzburg Institute of Computer Science Research Report Series, 2011.

[17] Howe, J., *The rise of crowdsourcing.* Wired magazine, 2006. **14**(6): p. 1-4.

[18] Burnap, A., et al., *When crowdsourcing fails: A study of expertise on crowdsourced design evaluation.* Journal of Mechanical Design, 2015. **137**(3): p. 031101.

[19] Abdalkareem, R., E. Shihab, and J. Rilling, *What do developers use the crowd for? a study using stack overflow.* IEEE Software, 2017. **34**(2): p. 53-60.

[20] Assefa, S. and V. Solms, *An Information Security Reference Framework for e-Learning Management Systems (ISRFe-LMS).* Proceedings of 9th WCCE, 2009.

[21] Yuen, M.-C., I. King, and K.-S. Leung. *A survey of crowdsourcing systems.* in *Privacy, Security, Risk and Trust (PASSAT) and 2011 IEEE Third Inernational Conference on Social Computing (SocialCom), 2011 IEEE Third International Conference on.* 2011. IEEE.

[22] Doan, A., R. Ramakrishnan, and A.Y. Halevy, *Crowdsourcing systems on the*

world-wide web. Communications of the ACM, 2011. **54**(4): p. 86-96.

[23] Lakhani, K.R., D.A. Garvin, and E. Lonstein, *Topcoder (a): Developing software through crowdsourcing.* 2010.

[24] Li, G., et al. *Crowdsourced Data Management: Overview and Challenges.* in *Proceedings of the 2017 ACM International Conference on Management of Data.* 2017. ACM.

[25] Ipeirotis, P.G., F. Provost, and J. Wang. *Quality management on amazon mechanical turk.* in *Proceedings of the ACM SIGKDD workshop on human computation.* 2010. ACM.

[26] Turk, A.M., *Amazon mechanical turk.* Retrieved August, 2012. **17**: p. 2012.

[27] Allahbakhsh, M., et al. *Reputation management in crowdsourcing systems.* in *Collaborative Computing: Networking, Applications and Worksharing (CollaborateCom), 2012 8th International Conference on.* 2012. IEEE.

[28] Wang, X., W. Wu, and Z. Hu. *Evaluation of software quality in the TopCoder crowdsourcing environment.* in *Computing and Communication Workshop and Conference (CCWC), 2017 IEEE 7th Annual.* 2017. IEEE.

[29] Anderson, A., et al. *Discovering value from community activity on focused question answering sites: a case study of stack overflow.* in *Proceedings of the 18th ACM SIGKDD international conference on Knowledge discovery and data mining.* 2012. ACM.

[30] http://www.crowdx.co, *Crowdx.* http://www.crowdx.co.

[31] Burkle, M. and Y. Sayed, *Integrating ICT in Higher Education: The Case of ITESM.* Mexico, International Journal of Education, 2001.

[32] Suganthy, A. and T. Chithralekha. *Application of crowdsourcing in software development.* in *Recent Trends in Information Technology (ICRTIT), 2016 International Conference on.* 2016. IEEE.

[33] Al Sohibani, M., et al., *Factors that influence the quality of crowdsourcing*, in *New Trends in Database and Information Systems II.* 2015, Springer. p. 287-300.

[34] Le, J., et al. *Ensuring quality in crowdsourced search relevance evaluation: The effects of training question distribution.* in *SIGIR 2010 workshop on crowdsourcing for search evaluation.* 2010.

[35] Allen, B., D. Chandrasekaran, and S. Basuroy, *Design Crowdsourcing: The Impact on New Product Performance of Sourcing Design Solutions from the "Crowd".* Journal of Marketing, 2017.

[36] Kaufmann, N., T. Schulze, and D. Veit. *More than fun and money. Worker Motivation in Crowdsourcing-A Study on Mechanical Turk.* in *AMCIS.* 2011.

[37] Ahad, A., et al., *Software Inspections and Their Role in Software Quality Assurance.* American Journal of Software Engineering and Applications, 2017. **6**(4): p. 105.

[38] Niu, X. and S. Qin. *A review of crowdsourcing technology for product design and development.* in *Automation and Computing (ICAC), 2017 23rd International Conference on.* 2017. IEEE.

[39] Saha, B. and D. Srivastava. *Data quality: The other face of big data.* in *Data Engineering (ICDE), 2014 IEEE 30th International Conference on.* 2014. IEEE.

[40] Wu, W., W.-T. Tsai, and W. Li, *An evaluation framework for software crowdsourcing.* Frontiers of Computer Science, 2013. **7**(5): p. 694-709.

[41] Dromey, R.G., *A model for software product quality.* IEEE Transactions on Software Engineering, 1995. **21**(2): p. 146-162.

[42] Mao, K., et al., *A survey of the use of crowdsourcing in software engineering.* Journal of Systems and Software, 2017. **126**: p. 57-84.

[43] Mason, W. and D.J. Watts, *Financial incentives and the performance of crowds.* ACM SigKDD Explorations Newsletter, 2010. **11**(2): p. 100-108.

[44] Zikmund, W.G., et al., *Business research methods.* 2013: Cengage Learning.

[45] Polonsky, M.J. and D.S. Waller, *Designing and managing a research project: A business student's guide.* 2014: Sage publications.

[46] DAVIS, D. and R.M. Cosenza, *BUSINESS RESEARCH FOR DECISION MAKING/DUANE DAVIS AND ROBERT M. COSENZA.* 2005.