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Challenges and Their Resolution in Crowdsourcing Based Team Formation

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Abstract- Crowdsourcing in software development is an emergent sourcing model in which geographically dispersed people collaborate and cooperate towards formation of teams for development of software projects. Teamwork can be successful if hired workers are professional and they effectively collaborate with one another, which is a key challenge in crowdsourcing. So, Team formation is difficult, especially at a large scale projects. In crowdsourcing team formation is where the requesters' hire socially connected workers to work as a team. This paper discusses the team formation issues in software crowdsourcing paradigm. This research is carried out in three steps: systematic literature review (SLR), survey and expert evaluation. SLR is further detailed as planning review, process execution review and results. Through SLR, forty raw challenges were identified, which were reviewed by experts to select main challenges. A survey was conducted on the resolution of main challenges, taking suggestions about resolution of the former. The validation of the challenges was performed on the basis of expert reviews. Through validation, it was ensured that the identified challenges had consistent and correct naming conventions and terminologies within existing state of knowledge.

Keywords- Software Development, Challenges, Crowdsourcing, Team Formation, Expert Reviews.

I. INTRODUCTION

Crowdsourcing is a method of assigning and completing an online tasks in which an individual, an organization, a nonprofit institute, or corporation proposes to a cluster of individuals of different knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task [i] and it is the process in which crowd is engaged collaboratively to achieve a goal. Crowdsourcing can be applied across different industries. It is now convenient for individuals to contribute together in a project with their ideas, time, expertise or funds due to growth of connectivity. This collective scope of features is crowdsourcing [ii]. It can provide new ideas and solutions to organizations, more consumer involvement, opportunities for co-creation, optimization of tasks and reduced costs. Organizations are closer to their stakeholders due to the internet and social media, so new ways of collaboration are emerging, with promises of value addition. Such an approach increases the productivity of a company. It also minimizes labor expenses. It has become an extremely effective tool due to enhanced involvement of customers in the company activities [ii]. It has become a flexible service computing standard, allowing universal availability of human resources to the recruiters for tasks completion. Team crowdsourcing has received greatest interest to deal with more complex tasks, e.g. software development. In team crowdsourcing, the recruiter hires a group of workers that can work together as a team for complex tasks completion. Team crowdsourcing approach mainly focuses on hiring professional workers that can complete each subtask with high-quality. However, teamwork can be successful if hired workers are professional and they effectively collaborate with each other [iii]. So, it is a key challenge to crowdsource a complex task to a team of professional and collaborative workers. Crowds formed through online communities have capabilities to accomplish complicate tasks. But team formation can be difficult to coordinate at large scales [iv]. There are various studies that report the challenges in team formation [i]. Crowdsourcing platforms affect the quality standards by allowing many unfit and unexperienced workers to work on the product [v].

Tracking down the term crowdsourcing, the idea has its roots in a problem known as the "The Longitude Problem" whose solver was announced an award of £20,000 by the British Government [vi]. One person, John Harrison was declared the winner. This is considered as the first official crowdsourcing example in the world. In 1936, Toyota invited people to redesign its logo. Out of 27,000 logo entries, one was selected as the best. This was a remarkable crowdsourcing event

with positive results [vi].

Since its inception, crowdsourcing is considered very effective as it allows workers connect through the internet without restrictions of boundaries and nationalities. Nevertheless, it is considered least manageable when teams and groups need to be created [vii].

Due to ever increasing efficiency achieved by crowdsourcing, new trends were set up and even more effective related techniques were introduced. In 1955, a contest was held to design the building for Sydney's Harbor. 233 entries from 32 countries were received, reflecting popularity of crowdsourcing [vii]. From 2000 to 2006, websites like YouTube or Wikipedia fanned the flames of crowdsourcing by putting tremendous efforts in creating databases, online connections and by managing the teams. In 2006, Jeff Howe introduced the term crowdsourcing for the first time. This is where the rise of this term started and people began noticing the benefits as well as issues in this field.

As of now, crowdsourcing is an established model of collaboration [vii]. The success of crowdsourcing depends on various factors such as communication, team formation, security and data management.

Section 2 discusses literature review, Section 3 methodology, Section 4 conduct of studies and Section 5 results. Finally Section 6 presents conclusion.

II. Literature Review

Crowdsourcing is a platform in which workers and requesters collaborate with each other from different locations to work on same project. Crowd sourcing is dealing with many complex challenges which are crowding platform effects the quality standards by allowing many unfit and inexperienced workers to work on the product, security privacy and data protection, communication issue between clients and workers, unqualified people, less motivated people and immature task designs[viii].

Some workers don't want to publicise their personal information so privacy and protection or their data is a risk for them. Crowdsourcing should overcome this challenge.

Many projects fail because of communication gaps between clients and workers. To achieve the desire result skilled workers are required but in crowdsourcing unqualified workers are the reason of unsuccessful projects. Working with unqualified workers affects the quality of product. It is difficult for the organizations to find qualified workers. Some times because of low benefit workers are unmotivated and they work according to the price of that project. If requester is giving fewer amounts for the project than worker utilize less effort on that project. So, workers should be motivated to work hard and make projects successful[ix].

The study "Team Dating: A Self-Organized Team Formation Strategy for Collaborative Crowdsourcing" consider the problems that emerge when online crowds undertake complex tasks in teams, instead of taking them individually [iv]. To solve these problems, "team dating" approach is suggested. Another study proposed a team formation model based on outsourcing obligations to social networks (SNs) in an effort to contract search space for seeded candidates [x]. The proposed model selects centrality professional listing to lessen communication cost. A study highlights the fact that obligations might also impose different talent requirements on employees, which may lead to decreased numbers of executed responsibilities in actual applications [xi]. To alleviate this effect, Team Orientated Task Planning is proposed, which is likely to generate sub-optimal but viable plans. The diversity problem in group formation is explored in many a work. Given a set of required competencies and a set of people each one of which has some talents, the idea is to form a team satisfying the requirements. The mapping becomes complex when team member variations (e.g. gender, race, house preferences and financial brackets) are also considered [xii]. The effect of personality compatibility on overall performance and individual perceptions in crowds is studied [xiii]. Using the DISC character, they made fourteen teams, each five-characters (N=70) with either a harmonious insurance of personalities (balanced) or a surplus of chief-type personalities (imbalanced). A crowdsourcing platform is presented that supports teamwork based on stories from a laboratory, focusing on comparison of traditional online crowdsourcing [xiv]. The described technique considers collocated work groups.

As compared to using real life networks for formation of appropriate teams, using SNs is non-trivial. The problem spans over fee elements and conversation overhead, while the related solutions are based on standards that hinder achieving balance between trade-offs. A suggestion is to undertake an empirical study to deeply probe into the finding the influencing factors [xv]. Crowdsourcing is leveraged on connections in SNs [xvi]. A method should be based on realistic capabilities of team members so as to achieve some goal optimally. One of many situations that can arise in online SNs is when connected people do not cooperate [xvii]. The suggestion is to increase connection base to increase chances of cooperation.

Interaction patterns between team members have impact on team performance [xviii]. For instance, relational clashes lower coordination. Sometimes cultural diversity affects team potency. A relevant study can inspect such differences towards identifying structures for strengthening the overall performance. Crowd-management has a vital role in success of crowds. It is affected by lack of operational help, which includes understanding data sources and setting up of subordinate intercession systems [xix].

A coordinated view yields operationally usable models. A survey is reported about crowdsourcing with initiative and proprietorship, attribution, coordination and strife [xx]. Lack of cooperation between team members can result in big issues thus impeding the group development process. There are ways to deal with such issues [xxi]. It is appropriate assess the intelligence level of crowds. To this end, an incentive based study was undertaken wherein business assignments based on commercial centers data was used [xxii]. Prizes were offered to resultant specialists. Task assignment to team members is challenging. Its optimization should be objective with an overall view. In general, coordinated task assignment is overlooked, thus suboptimal solution space emerges. To address this issue, coordinated effort is formalized towards comprehension of the problem extent [xxiii]. Another incentive based approach motivates team members to report their abilities honestly [xxiv]. Overheads due to incentives increase system maintenance costs. Nonetheless, it allows deep understanding of system. On the lines of better understanding optimization in task assignment, a framework is introduced to optimize the task assignment within the knowledge-intensive crowdsourcing (KI-C) [xxv]. A contributory work simulates situations to understand the advantage gained by avoiding conflicts in task assignment [xxvi]. It is also pointed out that problem prevention is itself not polynomial complete. Mutual cohesion and trust enhances the overall performance of a project undertaken and completed by teams [xxvii]. Similarly a Game Theoretical model identifies the need of trust to increase benefits [xxviii]. In such approaches, the emphasis is on honest opinions whenever sought. A downside of these types of approaches appears when the participation is low so that solution resultant due to system convergence is premature [xxix]. As a case study of team formation, eSports helps in both confirmation as well as augmenting the present theories. [xxx]. While making teams using connections in SNs, it is realistic to assume members have a disparity in abilities as well as that the incoming flows of tasks are unknown and unanticipated [xxxi]. Given a team, the goal is handle tasks. This is in contrast to static situations when teams are formed objectively to handle tasks. More realistic is this dynamic situation which reflects the change over time the connections in SNs, a frequent and well observed behavior [xxxi]. Teams can be formed on the competition model, wherein costs are minimized during crowdsourcing competitions [xxxii]. Team members are randomly assigned to one of the permanent teams, while teams compete against one another for monetary prizes.

A case study of boarding time is done in context of crowdsourcing. A statistical analysis of usual boarding sets the benchmark, which is compared to online crowd-sourced boarding. Issues such as task category, task duration and task country are studied [xxxiii]. A system "Huddler" is proposed to enable crowd meetings, even under random accessibility and inflexible time limitations [xxxiv]. With Huddler, crowd employees can align themselves with any number of teams and ask for a suitable team when they are able to accept a task. Another crowdsourcing framework is proposed for automatic discovery of sub-crowd to enhance information excellence within the information gathering process [xxxv]. The discovery is based on attributed of workers such as gender, education level, nationality and major etc., or even personality test score and some other screening measures. Another work focuses on understanding and considering cultural differences to mitigate differences between team members, thus steering objectives towards acceptability of cultures in "Global Virtual Teams" [xxxvi]. This approach develops knowledge of national civilizations and their effects on utilization their strengths effectively. However, little work is done in implementation of these objectives in tools. The problem of team formation in SNs and its related issues are also addressed using the densest sub-graph approach [xxxvii]. The method allows modeling of many practical requirements such as addition of a chosen group leader or a group of selected professionals, constraining cost and consideration of team's geographical locality. For non-cooperative SNs, characterized by selfish behaviors, negotiations allow trade-offs [xxxviii]. This type of SNs is considered to reflect realistically the real world and operate in a distributed manner in contrast to central manner. Another aspect to consider for team formation is the team size [xxxix]. It has a direct impact on performance. It has been pointed out that a thoroughly coordinated team compensates for negativity due to social loafing. there is also an trust issue when forming a team for crowdsourcing that companies may feel that the formulated team may cheat and exploit which may result compromising the reputation of company, so trust issue is also a challenge faced by companies while formation of team in the process of crowed sourcing [ii]. Sometimes the team selected for crowdsourcing may have dissimilar levels of expertise which are sometimes not enough for doing specific tasks [xl]. The presented works signifies the role of team formation in professional environments. Collaborations to complete a project do not come easy and there is no notion of an ideal team formation. As of now, there is a lack of a systematic study that identifies challenges that arise during team formation in crowdsourcing. This work is a step towards fulfilment of this gap. Highlighting these challenges leverage methods to deal with them appropriately and enable Managers and recruiters to estimate resources and predict progress a priori. Thus optimal solutions are possible. Specifically, our research questions are:

Rq1: What are different challenges in crowdsourcing with respect to team formation?

Rq2: How to resolve the challenges in team formation in crowdsourcing?

III. METHODOLOGY

The main objective of our research is to Investigate Challenges and their Resolution in Crowd sourced Team Formation. The purpose of SLR in this research is to extend its three phases: review planning, review conduction and review reporting.

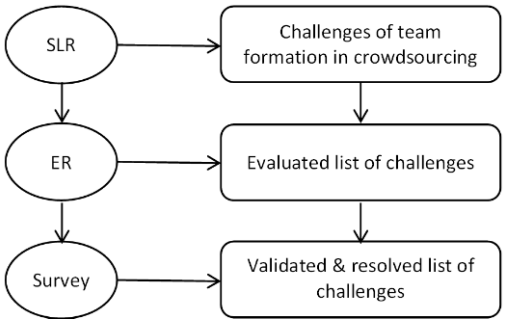

Fig. 1: The steps taken to conduct our study. SLR and ER stand for Systematic Literature Review and Expert Review, respectively.

In SLR papers are selected and critically analyzed according to a well-defined protocol. We performed SLR to identify the challenges related to team formation process in crowdsourcing, following the approach of Kitchenham [xli]. The purpose of SLR in this research is to extend its three phases: review planning, review conduction and review reporting. The schematic of the steps taken in our work are shown in Fig. 1. First of all review planning is done to find challenges related to team formation process in crowdsourcing. For searching journal papers, conference papers and published theses of our interest, we used following search strings: “team formation related challenges in crowdsourcing environment”, “challenges in team formation in crowdsourcing”, “challenges in crowdsourced team formation” , “crowdsourced team formation” and “team formation in crowdsourcing” [x]. Sources of four high quality publishers, listed in Table I were used for search within the period 2011 to 2018. Selection of this period is due to recent increasing trend of crowdsourcing and reporting of associated issues. Some 100 papers were initially shortlisted and later the filters were applied on the selections. The filters covered the time, relevance, trustworthiness with the search terms. Finally 23 papers were selected to conduct the SLR.

Table I: Searched Sources.

Data Base	URL
IEEE	https://ieeexplore.ieee.org/Xplore
ACM	https://www.acm.org
Science Direct	https://www.sciencedirect.com
Springer	https://www.springer.com

The criterion of selecting the papers is discussed next. We applied exclusion criterion first, which is defined by those papers which consist only table of contents and whose titles, keywords and abstracts don't match our topic. Next we applied inclusion criterion, which is defined by those papers which discuss team formation related challenges in crowdsourcing. We checked title, keywords and abstract for relevance to our topic. The outcome of inclusion/exclusion stage passes through the quality assessment stage (QAS). During QAS, a checklist is generated using the guidelines given by Kitchenham [xli]. The scale for quality measurement was also taken from the same work. It measures high score as 1 ('yes'), medium score as 0.5 and low score as 0. Papers with high score were selected.

In data extraction strategy, data is extracted from finally selected papers along with their summaries. With the help of collected data, we are able to answer the question: What are different types of team formation related challenges in crowd sourcing? Once the challenges are identified, a survey has been conducted to identify challenges regarding team formation in crowd sourcing. They are forwarded to experts for evaluation [xlii], [xliii]. The first step in expert evaluation is making a selection criterion for experts. The second step is selection of experts. Next experts are familiarized with issues and their responses collected, followed by presentation of results. The experts in our case are Software Engineers, for which we sampled students and teachers of Computer Science and related disciplines due to ease of access to them. After selection of experts, a list of identified challenges is given to them for their intellectual advice regarding naming conventions, terminologies, and suggestions for any new challenges. Once the reviewed lists of challenges are finalized, the survey was conducted according to the recommendation given by Kasunic [xliv]. In his publication by Software Engineering Institute (SEI). These recommendations are followed due to their seminal value. Survey research is a popular data gathering mode. It is featured by the questionnaire set for the purpose.

IV. CONDUCT OF STUDIES

SLR was conducted for identifying different type of challenges faced in team formation in crowdsourcing. After conducting SLR, expert review (ER) through survery was conducted to identify challenges regarding team formation in crowdsourcing. The same were forwarded for further evaluation. In SLR, papers satisfying inclusion/exclusion criteria were assigned unique IDs, which are shown in Appendix I. For ER, two experts were contacted. They reviewed the work for conflicts, suggested proper and professional wording of conflicts and removed unwanted data. Appendix II shows the comments of experts regarding challenges.

After the conduction of SLR and ER, we formed questionnaires similar to the work of Kasunic [xliv].

V. Results

The determined challenges are presented in this section, along with industry recommended solutions. The skills of team members can be identified by:

1. The knowledge that his/her is sharing and performance on a particular task.
2. Through communication that indicates about abilities for appropriate placement in groups.
3. Participation with other team members for small group tasks for awareness of skills, which leverage better placement for large group tasks.
4. Monitoring the progress of tasks assigned to them.
5. Their previous experience.
6. Engaging them in different problems.
7. Getting feedback from colleagues.
8. The quality of the work done.
9. Feelings of exploitation and being cheated that may jeopardize their success.
10. The selected team may have different expertise than needed for a specific task.

These above listed aspects help in identification of skills of team members. By focusing on these aspects, related issues can be resolved. Planning issues can be resolved by managing time, budget, cost and workers. By planning, proper resources for each task can be allocated. Budgeting and forecasting skills can help in minimizing the planning issues. In case of budget constraints, interns and volunteers can be hired. Communication issue can be resolved through openness. Openness means self-disclose when appropriate. Openness also includes a willingness to listen openly and to react honestly to the messages of others. Workers must listen mindfully and respond spontaneously with appropriate honesty [iii]. As explained earlier, feelings of exploitation and being cheated can be resolved with better communication and openness [xl]. Challenge of individualism can be solved by involving everyone in the decision making process, by communicating with the team, having team building activities, by giving powers of self-management to the team following some process like Agile, by giving confidence and ownership, most importantly trusting workers --- also equally important are explaining the end goal and raising awareness about its importance, reducing communication gap and avoiding forceful decisions. The challenge of schedules can be solved by making realistic schedules. The challenge of varying team size can be tackled by making small teams, e.g. team size of maximum five members. The challenge of quality can be solved by hiring only skilled workers. In short, team formation challenges in crowdsourcing can be resolved by reducing communication gap, by clearly defining tasks, checking on information gathered through crowdsourcing, carrying out such activities which improves confidence, making workers comfortable for performance boost, emphasizing on problem solving approach, offering a friendly environment, listening and valuing opinions, redefining hiring processes, adjusting criteria of resource usage evaluation, forming teams of people with different skills etc.[xlv-lix].

VI. Conclusion

Team formation in crowdsourcing is difficult to manage. It is analyzed that different kinds of challenges are faced during/after team formation in crowdsourcing. This study was about appropriate resolution of these challenges. Challenges were identified by deep observation, SLR and ERs. By using the methods mentioned here, numerous challenges in team formation in a crowdsourcing environment were identified. The mitigation strategy for the identified challenges has also been proposed to deal with the challenges. It is expected that the proposed mitigation strategies are capable to deal with the identified challenges.

VII. Future Work

Team formation in crowdsourcing is not trivial. We identified challenges in this process and gave expert opinion to deal with them. In future we plan to prioritize these challenges according to their urgency and criticality. We also consider interesting to study the inter-dependency of challenges.

References

[1] L. Zanatta, I. Steinmacher, L. S. MacHado, C. R. B. De Souza, and R. Prikladnicki, "Barriers Faced by Newcomers to Software-Crowdsourcing Projects," IEEE Softw., vol. 34, no. 2, pp. 37–43, 2017.

[2] S. Djelassi and I. Decoopman, "Customers' participation in product development through crowdsourcing: Issues and implications," Ind. Mark. Manag., vol. 42, no. 5, pp. 683–692, 2013.

[3] W. Li, C. Zhang, Z. Liu, and Y. Tanaka, "Incentive mechanism design for crowdsourcing-based indoor localization," *IEEE Access*, vol. 6, pp. 54042–54051, 2018.

[4] M. N. Malik and H. H. Khan, "Investigating Software Standards: A Lens of Sustainability for Software Crowdsourcing," *IEEE Access*, vol. 6, pp. 5139–5150, 2018.

[5] W. Wang et al., "Strategic Social Team Crowdsourcing: Forming a Team of Truthful Workers for Crowdsourcing in Social Networks," *IEEE Trans. Mob. Comput.*, pp. 1–14, 2018.

[6] C. Zhu, G. Pastor, Y. Xiao, and A. Ylajaaski, "Vehicular Fog Computing for Video Crowdsourcing: Applications, Feasibility, and Challenges," IEEE Commun. Mag., vol. 56, no. 10, pp. 58–63, 2018.

[7] J. Howe, "The Rise of Crowdsourcing," *Wired Magazine,* no. 14, 2006.

[8] J. Phuttharak and S. W. Loke, "A Review of Mobile Crowdsourcing Architectures and Challenges: Toward Crowd-Empowered Internet-of-Things," IEEE Access, vol. 7, pp. 304-324, 2019.

[9] S. Levy, "Howe - The Rise of Crowdsroucing," Wired Mag., no. 14, pp. 1–5, 2006.

[10] Y. Sun, W. Tan and L. Huang, "A team discovery model for crowdsourcing tasks to social networks," *International Journal of Web Engineering and Technology,* vol. 12, no. 1, pp. 21-44, 2017.

[11] D. Gao, Y. Tong, Y. Ji and K. Xu, "Team-Oriented Task Planning in Spatial Crowdsourcing," in *APWeb and WAIM joint Conference*, 2017.

[12] S. Cohen and M. Yashinski, "Crowdsourcing with Diverse Groups of Users," in *ACM SIGMOD/PODS Conference*, Chicago, 2017.

[13] Lykourentzou, A. Antoniou, Y. Naudet and S. P. Dow, "Personality Matters: Balancing for Personality Types Leads to Better Outcomes for Crowd Teams," in *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing*, San Francisco, 2016.

[14] S. Hosio, J. Goncalves, N. V. Berkel, S. Klakegg, S. Konomi and V. Kostakos, "Facilitating Collocated Crowdsourcing on Situated Displays," pp. 1–37, 2017.

[15] X. Wang, Z. Zhao and W. Ng, "USTF:A Unified System of Team Formation," *IEEE Transactions on Big Data,* vol. II, no. 1, pp. 70 – 84, 2016.

[16] W. Wang, Z. He, P. Shi, W. Wu and Y. Jiang, "Truthful Team Formation for Crowdsourcing in Social Networks," in *Proceedings of the 2016 International Conference on Autonomous Agents & Multiagent Systems*, Singapore, 2016.

[17] W. Wang, J. Jiang, B. An, Y. Jiang and B. Chen, "Toward Efficient Team Formation forCrowdsourcing in Noncooperative Social Networks," *IEEE Transactions on Cybernetics,* vol. PP, no. 99, pp. 1–15, 2016.

[18] C. Troster, A. Mehra and D. V. Knippenberg, "Structuring for team success: The interactive effects of network structure and cultural diversity on team potency and performance," *Organizational Behavior and Human Decision Processes,* vol. 124, no. 2, pp. 245–255, 2014.

[19] N. Wijermans, C. Conrado, M. V. Steen, C. Martella and J. Li, "A landscape of crowd-management support: An integrative approach," *Safety Science,* vol. 86, pp. 142–164, 2016.

[20] Y. Pan and E. Blevis, "A Survey of Crowdsourcing as a means of Collaboration and the Implications of Crowdsourcing for Interaction Design," in *Collaboration Technologies and Systems (CTS), 2011 International Conference on Collaboration Technologies and Systems (CTS)*, Philadelphia, 2011.

[21] C. T. Li and M. K. Shan, "Team Formation for Generalized Tasks in Expertise Social Networks," in *Social Computing (SocialCom), 2010 IEEE Second International Conference on Social Computing*, Minneapolis, 2010.

[22] M. Kosinski, Y. Bachrach, G. Kasneci, J. V. Gael and T. Graepel, "Crowd IQ: Measuring the Intelligence of Crowdsourcing Platforms," *Web Science,* 2012.

[23] H. Rahman, S. B. Roy, S. Thirumuruganathan, S. A. Yahia and G. Das, "Task Assignment Optimization in Collaborative Crowdsourcing," in *Data Mining (ICDM), 2015 IEEE International Conference on Data Mining*, Atlantic City, 2015.

[24] Y. Wang, J. Huang, Q. Jin and J. Ma, "ABT: an effective Ability-Balanced Team-based incentive mechanism in crowdsourcing system," in *Advanced Cloud and Big Data (CBD), 2017 Fifth International Conference on Advanced Cloud and Big Data (CBD)*, Shanghai, 2017.

[25] S. B. Roy, I. Lykourentzou, S. Thirumuruganathan, S. A. Yahia and G. K. Das, "Task assignment optimization in knowledge-intensive crowdsourcing," *The VLDB Journal — The International Journal on Very Large Data Bases,* vol. 24, no. 4, pp. 467–491, 2015.

[26] H. Zhu, "Avoiding Conflicts by Group Role Assignment," IEEE Transactions on Systems, Man, and Cybernetics: Systems, vol. 46, no. 4, pp. 535–547, 2016.

[27] R. Paul, J. R. Drake and H. Liang, "Global Virtual Team Performance: The Effect of Coordination Effectiveness, Trust, and Team Cohesion," IEEE Transactions on Professional Communication, vol. 59, no. 3, pp. 186–202, 2016.

[28] X. Ma, J. Ma, H. Li, Q. Jiang and S. Gao, "RTRC: a reputation-based incentive game model for trustworthy crowdsourcing service," China Communications, vol. 13, no. 12, pp. 199–215, 2016.

[29] G. Freeman and D. Y. Wohn, "Understanding eSports Team Formation and Coordination," *Computer Supported Cooperative Work (CSCW),* pp. 1–32, 2017.

[30] Anagnostopoulos, L. Becchetti, C. Castillo,

A. Gionis and S. Leonardi, "Online Team Formation in Social Networks," in *Proceedings of the 21st international conference on World Wide Web*, Lyon, 2012.

[31] M. Rokicki, S. Zerr and S. Siersdorfer, "Groupsourcing: Team Competition Designs for Crowdsourcing," in *Proceedings of the 24th International Conference on World Wide Web*, Florence, 2015.

[32] K. Abhinav, A. Dubey, G. Virdi and A. Kass, "Analyzing On-Boarding Time in Context of Crowdsourcing," in *Proceedings of the 2nd International Workshop on Software Analytics*, Seattle, 2016.

[33] N. Salehi, M. A. Valentine, A. McCabe and M. S. Bernstein, "Huddler: Convening Stable and Familiar Crowd Teams Despite Unpredictable Availability," in *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing*, Portland, 2017.

[34] H. Li, B. Zhao and A. Fuxman, "The wisdom of minority: discovering and targeting the right group of workers for crowdsourcing," in *Proceedings of the 23rd international conference on World wide web*, Seoul, 2014.

[35] H. A. He, N. Yamashita, C. Wacharamanotham, A. B. Horn, J. Schmid and E. M. Huang, "Two Sides to Every Story: Mitigating Intercultural Conflict through Automated Feedback and Shared Self-Reflections in Global Virtual Teams," *Proceedings of the ACM on Human-Computer Interaction,* vol. 1, 2017.

[36] S. S. Rangapuram, T. Buhler and M. Hein, "Towards realistic team formation in social networks based on densest subgraphs," in *Proceedings of the 22nd international conference on World Wide Web*, Rio de Janeiro, 2013.

[37] W. Wang and Y. Jiang, "A Practical Negotiation-Based Team Formation Model for Non-cooperative Social Networks," in *Tools with Artificial Intelligence (ICTAI), 2014 IEEE 26th International Conference on Tools with Artificial Intelligence*, Limassol, 2014.

[38] Mao, W. Mason, S. Suri and D. J. Watts, "An Experimental Study of Team Size and Performance on a Complex Task," 2016.

[39] B. Benatallah, F. Daniel, P. Kucherbaev, M. Allahbakhsh, and C. Cappiello, "Quality Control in Crowdsourcing," *ACM Comput. Surv.*, vol. 51, no. 1, pp. 1–40, 2018.

[40] B. Kitchenham and S Charters, "Guidelines for performing Systematic Literature Reviews in Software Engineering," pp. 1–57, 2007.

[41] R. Boring, D. Gertman, J. Joe, J. Marble, W. Galyean, L. Blackwood and H. Blackman, "Simplified Expert Elicitation Guideline For Risk Assessment Of Operating Events," Washington, 2005.

[42] M. Ayyub, "A Practical Guide on Conducting Expert-Opinion Elicitation of Probabilities and Consequences for Corps Facilities," Alexandria, 2001.

[43] M. Kasunic, "Designing an Effective Survey," p. 1–143, 2005.

[44] B. Shehzad, K. M. Awan, M. I.-U. Lali, and W. Aslam, "Identification of Patterns in Failure of Software Projects," *J. Inf. Sci. Eng.*, vol. 33, no. 6, pp. 1465–1480, 2017.

[45] M. Abdullatif, B. Shahzad, and A. Hussain, "Evolution of Social Media in Scientific Research: A Case of Technology and Healthcare Professionals in Saudi Universities," *J. Med. Imaging Health Inform.*, vol. 7, no. 6, pp. 1461–1468, 2017.

[46] Shahzad, "Identification of Risk Factors in Large Scale Software Projects: A Quantitative Study," *Int. J. Knowl. Soc. Res. IJKSR*, vol. 5, no. 1, pp. 1–11, 2014.

[47] B. Shahzad and A. Said, "Application of quantitative research methods in identifying software project factors," *Int. J. Inf. Technol. Electr. Eng.*, vol. 1, no. 1, pp. 30–33, 2012.

[48] K. Saleem, A. Derhab, J. Al-Muhtadi, and B. Shahzad, "Human-oriented design of secure Machine-to-Machine communication system for e-Healthcare society," *Comput. Hum. Behav.*, vol. 51, pp. 977–985, 2015.

[49] K. Saleem, A. Derhab, J. Al-Muhtadi, B. Shahzad, and M. A. Orgun, "Secure transfer of environmental data to enhance human decision accuracy," *Comput. Hum. Behav.*, vol. 51, pp. 632–639, 2015.

[50] J. Al-Muhtadi, B. Shahzad, K. Saleem, W. Jameel, and M. A. Orgun, "Cybersecurity and privacy issues for socially integrated mobile healthcare applications operating in a multi-cloud environment," *Health Informatics J.*, p. 1460458217706184, 2017.

[51] M. I. U. Lali, R. U. Mustafa, K. Saleem, M. S. Nawaz, T. Zia, and B. Shahzad, "Finding healthcare issues with search engine queries and social network data," *Int. J. Semantic Web Inf. Syst. IJSWIS*, vol. 13, no. 1, pp. 48–62, 2017.

[52] Shahzad, E. Alwagait, S. Alim, and I. Resaercher, "Investigating the relationship between social media usage and students grades in Saudi Arabia: A mixed method approach," *Recent Adv. Electr. Eng. Educ. Technol.*, pp. 211–214, 2015.

[53] R. A. Abbasiet al., "Saving lives using social media: Analysis of the role of twitter for personal blood donation requests and dissemination," *Telemat. Inform.*, vol. 35, no. 4, pp. 892–912, 2018.

[54] Alwagait, B. Shahzad, and S. Alim, "Impact of social media usage on students academic performance in Saudi Arabia," *Comput. Hum. Behav.*, vol. 51, pp. 1092–1097, 2015.

[55] Shahzad and E. Alwagait, "Does a change in weekend days have an impact on social networking activity?," *J UCS*, vol. 20, no. 15, pp. 2068–2079, 2014.

[56] Shahzad, Basit, and Jon Crowcroft. "Trustworthy Electronic Voting Using Adjusted Blockchain Technology."*IEEE ACCESS* vol. 7 (2019): 24477–24488.

[57] Shahzad, Basit, and Esam Alwagait. "Utilizing technology in education environment: A case study." *In 2013 10th International Conference on Information Technology: New Generations,* pp. 299–302. IEEE, 2013.

[58] Shahzad, Basit, and Esam Alwagait. "Does a change in weekend days have an impact on social networking activity?."*J. UCS* 20.15 (2014): 2068–2079.

[59] Shahzad, Basit, Ihsan Ullah, and Naveed Khan. "Software risk identification and mitigation in incremental model." *In 2009 International Conference on Information and Multimedia Technology*, pp. 366–370. IEEE, 2009.

APPENDIX I

Paper ID	Paper Title
P1	Team Dating: A Self-Organized Team Formation Strategy for Collaborative Crowdsourcing [x]
P2	A Team Discovery Model for Crowdsourcing Tasks to Social Networks [xi]
P3	Team-Oriented Task Planning in Spatial Crowdsourcing [xii]
P4	Personality Matters: Balancing for Personality Types Leads to Better Outcomes for Crowd Teams [xiv]
P5	A Unified System of Team Formation [xiii]
P6	Truthful Team Formation for Crowdsourcing in Social Networks [iii]
P7	Toward Efficient Team Formation for Crowdsourcing in Non-cooperative Social Networks [xviii]
P8	Team Dating Leads to Better Online Ad Hoc Collaborations [40]
P9	A Survey of Crowdsourcing as a means of Collaboration and the Implications of Crowdsourcing for Interaction Design [xxi]
P10	Team Formation for Generalized Tasks in Expertise SNs [xxii]
P11	Crowd IQ: Measuring the Intelligence of Crowdsourcing Platforms [xxiii]
P12	ABT: An Effective Ability-Balanced Team-Based Incentive Mechanism in Crowdsourcing System [xxv]
P13	Task Assignment Optimization in Knowledge Intensive Crowdsourcing [xxiv]
P14	Global Virtual Team Performance: The Effect of Coordination Effectiveness, Trust, and Team Cohesion [xxviii]
P15	RTRC: A Reputation-Based Incentive Game Model for Trustworthy Crowdsourcing Service [xxix]
P16	Analyzing On-Boarding Time in Context of Crowdsourcing [xxxiii]
P17	Huddler: Convening Stable and Familiar Crowd Teams Despite Unpredictable Availability [xxxiv]
P18	The Wisdom of Minority: Discovering and Targeting the Right Group of Workers for Crowdsourcing [xxxv]
P19	A Practical Negotiation-Based Team Formation Model for Non-Cooperative SNs [xxxviii]
P20	An Experimental Study of Team Size and Performance on a Complex Task [xxxix]

APPENDIX II

Challenges, the relevant papers and comments of experts are given here.

1. Challenges: Cultural issues, interpersonal relationship, knowing the team's abilities, not enough info of workers on their profiles, estimation of task-specific and interpersonal qualities, evaluate potential co-workers (skills and compatibility issues), finalizing team members, the cost of experts, interaction efficiency, identification of a good leader, adjustment of team formation strategy not suitable to select workers of required skills, mismatch of interpersonal compatibility, matching people based on individual characteristics.
Papers: P1, P2, P8, P12
Comments: Per comments of expert, these challenges can be addressed by identifying skills of workers and matching them to skill names.

2. Challenges: Planning problem (travel budgets, completion time), cost for experts, team size, costs of coordinated work increase with the number of workers, forming a minimal team of experts that can collectively cover all the required skills, cost function, sub-optional constraints that include personnel cost, packing constraint and workload balancing, optimization of task assignment
Papers: P3, P5, P20, P13
Comments: Experts suggest proper naming of planning issues.

3. Challenges: Personality compatibility, improvement of team formation, communication, collaboration.
Papers: P4, P10
Comments: Experts suggest proper naming of communication challenges.

4. Challenges: Selfish behavior, finding professionals, collaborative workers, time issue for short projects, design mechanism problem, spending extra time in on-boarding a worker for small task, selfish nature of individuals.
Papers: P6, P16, P19
Comments: Experts suggest proper naming of individualism challenges.

5. Challenges: Exertion level applied by workers.
Papers: P11
Comments: Experts suggest proper naming of exertion levels, for instance, "tight scheduling".

6. Challenges: To design a proper mechanism such that the crowds help to give correct information, to deal with low participation of crowd members that is an obstacle to the use of crowdsourcing, team-based coordination infeasibility, unavailability of team members.
Papers: P15, P17
Comments: Experts suggest proper naming of flexible size challenges.

7. Challenges: Expected performance from workers is highly desired in crowdsourcing, adoption of a mechanism to support hiring quality workers is an important practical problem.
Papers: P18
Comments: Experts suggest proper naming of quality challenges.