An Empirical Study on Continuous Delivery Process
Research Report

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I. GROUP MEMBERS PARTICIPATION

The group members participated in idea creation and report writing with the following amount of involvement.

Group Member	Idea Creation	Report Writing
Neeraj Reddy Avutu	50%	50%
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Abstract- Continuous delivery(CD) is pulling in increasing acknowledgement as a result of its benefits. Implementing CD in software delivery has become a complex task in terms of technical and organizational aspects. This research report is based on a survey which aims at architectural issues in continuous delivery and the need for architecting continuous delivery. The main aim of our research is to find challenges in implementing CD and ensuring reliability. The results show whether CD is a good approach for software delivery and how to main customer involvement in CD

II. INTRODUCTION

Developing a software has become a complex task keeping in mind, the quality we define for it. We realize the value of a software when it is delivered, but not when it is being developed. Today, the ultimate goal of any software development organization is to meet the expectations of their clients by generating valuable software through continuous delivery process.

Continuous Delivery(CD) can be defined as a software engineering practice where a development team releases software incrementally in short-periods and ensures that it can be released at any time into the market reliably[1] . CD works as an extension to the Continuous Integration process consisting of a set of workflows for automation of build and test cases[2]. Simplifying the software release, CD allows smaller response-cycles between developers and customers A number of companies have increased their investment in CD due to the benefits associated with it like "reliable releases, increase in the product quality and productivity, accelerated time to market and better customer satisfaction" [3].

The advancement of agile development and the late predominance of virtualization and cloud computing has altered the software delivery process, helping the organizations to discharge their product continuously[4]. Therefore, to diminish the problems like delayed delivery, excess delivery cost and poor quality delivered, there is a need for effortless, monotonous and reliable Continuous delivery process [4].

A number of post-development issues like "configuration management", poor cooperation among stakeholders, deficient testing, software incompatibility etc. are the motivation for Continuous Delivery activity [5].

Continuous delivery, also known as agile delivery ensures that the system behaves as required before classifying it as "release candidates" [5]. To implement CD, we need a deployment pipeline that suits the requirements of the project. The reliability issue in Continuous deployment has profound influence on the users of the software and the income of the organization. Most software deliveries are unreliable only when the deployment.

In order to practice CD effectively there are a set of "Architecturally Significant Requirements" (ASR's) that have to be met by software applications [1]. This research might introduce certain areas to the architects, that they must not neglect while architecting software for CD [1]. To maximize the benefits from CD, besides gathering customer requirements and etiquette, we must also ensure customer involvement. Customer involvement refers to the extent to which the users/customers participate in the software development process purposely or unintentionally. It reduces Research and Development costs and at same time maximizes product performance [6]. There are a few potential challenges for the implementation of involving customers in CD and overcoming them is one of the ways to enhance customer involvement.

The main objective of our research is to address the challenges in implementing CD and ensuring reliability. We also address the importance of architecting CD and the issues involved in it. We

present a few ways of enhancing customer involvement in CD.

The structure of the research report is as follows: the background and motivation behind the research are presented in Section III. Section IV presents research definition and research plan followed by describing the research operation in Section V. Furthermore, the data analysis and interpretation are described in Section VI. Section VII describes results, presents validity threats and limitations to our research. Section VIII presents summary of our research and further research that can be carried out to enhance the scope and quality of presented research.

III. BACKGROUND AND MOTIVATION

Continuous Delivery is the trending topic in the present software industry, seeking a lot of attraction and that has led to select this area for research. To narrow down the topic we referred a number of articles from the database and analyzed the problems, both in implementing and enhancing the performance of CD. The post-development issues of software have stood as the main motivation for implementing CD and making its use efficient.

In reference [1], the author describes the importance to architect for CD, depict the ramifications of architecting for CD and the various challenges associated with it. The author conducts a case study on implementing architecture for CD by addressing the context of his own organization (Paddy Power). The author discusses ASR's that imply the architecture, considering the CD context instead of traditional software development. The main challenge found while reviewing the article was that, all the applications in an organization did not meet these ASR's and moving them to CD was difficult.

In reference [3], the authors have addressed how to implement CD effectively using the CD pipeline. The results in this research were enough for effective software delivery.

In reference [6], the authors tackle the problem of less customer involvement in CD. Besides understanding the importance of customer involvement in CD, we also learn different challenges faced in implementing it and also the management of customer data in a continuous process.

In reference [4], the authors have tackled the problem of creating a repetitive and risk-free continuous development process by creating a system dynamics model (SD). Here the author uses agile software development approach to implement this. In reference [4], the authors also addressed the impact on CD process by changing the variables of

software projects and implementing agile practices. In reference [2], the authors discuss the implementation of continuous delivery process in a multi-customer project in order to simplify the feedback process and understandability of requirements. The authors also implement a method for integrating CD workflow and roles of release managers.

Reference [3] supported us to gain enough knowledge about CD. In this article the author addressed the benefits of CD, implementation of CD pipeline and the various methods to use it efficiently. The author considered his own organization as sample to test the CD process. Motivated by its benefits the author invested a lot in CD and moved applications.

IV. RESEARCH AND PLAN

A. Research objective

The main aim of our research is to address the challenges faced in implementing CD process and ensuring reliability in it. Our research also focuses on customer involvement in CD and the various issues in it. The research is also aimed at finding opinions about architecting CD process. These aims are achieved by fulfilling the following objectives:

- Addressing the challenges in implementing CD
- Achieving reliability in CD through automating the deployment process
- Conduct survey to find opinions about enhancing the software delivery process through customer involvement.
- Qualitative analysis of data collected.
- Through analysis specify the challenges for customer involvement in CD, so that we can enhance their coordination.

B. Research questions

We started our research by conducting SLR focusing on the challenges in implementing CD and constructing an architecture for CD. Based on this study, we formed two research questions. But later after finding a gap in the research, we narrowed our topic to reliability issue and reformulated the research question. After referring a number of articles we also found a need for enhancing the CD process by coordinating customer involvement. The following research questions were formed as a result:

RQ:1 What are the challenges faced in implementing Continuous Delivery(CD) process?
RQ:2 What are the challenges faced in ensuring reliability in CD?

RQ:3 How can we enhance the coordination and management of customer involvement in CD?
The answers to the above research questions are collected through confirmations accumulated from the survey.

C. Research method

Ignoring the depth of knowledge and realizing the generality of outcome we choose survey as our research method instead of other methods like action research, case study, experimentation etc. We used empirical survey method to compare and explain the knowledge, attitudes and behavior of our target population towards Continuous delivery process. Reference [7] helped us to choose the research method, discussing the kind of questions each method can address.

The survey questions were kept simple and unambiguous and were framed in such a way that we get qualitative answers from the respondents. Survey method best suits our research as we choose to address the challenges in CD process. It is also much efficient to generalize the results from the survey than experimentation.

Throughout the survey, we maintained "constructivist" attitude as mentioned in reference [7], so that we can focus more on the attitudes and thinking of the people rather than theories.

D. Units of analyzing

Considering software deliveries and projects as our units, we use non probabilistic sampling for selecting our respondents. Out of the different non-probabilistic methods, we have chosen convenience sampling. As our research questions are related to software delivery and release management, we have chosen professionals from particular software areas from different multi-national companies from India and United states to ensure reliability of the survey. We concentrated on the below aspects while selecting our target population.

- Experience: To attain confidence on the survey
- Designation: To observe behaviors of people from different perspectives.
- Expecting time from respondents

E. Data Collection methods

To conduct the survey and collect the data required for research, we first obtained the email list of software professionals from India and the United States through known references. After this the qualitative data for the research was collected by using questionnaires and interviews. Here, respondents with proper knowledge in Continuous delivery process answered our questionnaire. In this

process the questions must be asked in the right way to conduct a successful survey [8]. Keeping in mind the guidelines for conducting survey, the questionnaire (Appendix A) was carefully framed [9]. The first part of the questionnaire is intended to know the respondent's knowledge in the subject area while the second part focuses on the aims of the research.

We used the google drive options to create google forms in order to conduct the questionnaire. The following additional documents were present in our mail:

- Contents of cover letter
  1. Person/group conducting the survey
  2. Reason for survey
  3. Estimated time to complete survey
  4. Information about usage of results.
  5. Contact details for further suggestions
- Questionnaire link
- Express acknowledgement.

Responses found were recorded in the excel sheets. Further interviews were conducted if any responses sent by the respondents seemed promising and interesting.

F. Data analysis method

Grounded Theory Analysis was used to break down and interpret the qualitative data obtained from the survey. "Grounded theory is a qualitative research approach that can be used to build theory from empirical data in an explorative fashion" [10]. The ability to coordinate and streamline the data collection and analysis methods is the reason that inspired us to select this method. The theory is not formulated initially but, is driven from the resulted data. Thus we can expect that the theory formulated is reliable and valid [11]. To perceive the response patterns, we conducted statistical analysis and presented them through pie chart in section VI.

V. RESEARCH OPERATION

A. Research operation

We started our research by forming a team of two members and decided on the topic of Continuous delivery in software development. We carried out our systematic literature review for a span of one and half month to gain more knowledge in the domain.

The above flowchart represents the sequence of research activities done after conducting SLR and acceptance of Research proposal. As mentioned in Section III, the motivation of our research led us to find the research gap of challenges in ensuring reliability in CD and enhancing the management of

customer involvement in CD. Then we formed the research questions and analyzed different research methods that would suit our questions. We selected empirical survey as our research method and conducted questionnaires and telephonic interviews. In this way we started focusing on collecting data required for further research. Telephonic interviews were recorded and used for later analysis. The people who could not participate in the survey were sent reminder mails. Enough response time of 17 days was given to the respondents. To identify the target population, we opted for convenient sampling.
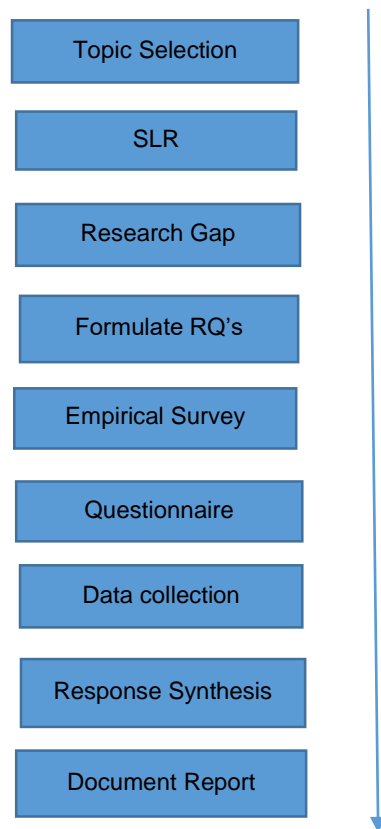

Figure 1: Flow chart for data analysis

A total of 30 responses were expected and this unanimity was reached keeping in mind the popularity of the domain in software development. After the duration of 17 days a total of 23 responses were received. These 23 responses captured are used for analysis. Out of these around 6 responses were rejected based on the following exclusion criteria:

- ➢ Unacquainted with the domain research - Based on answers to the initial part of questions.
- ➢ Incomplete survey

So we selected 17 responses for analysis.

The principle assumptions that were made before conducting the research are that the respondents have knowledge in the particular domain the researcher wants and the research situation does not influence the nature of answers [12].

The collected data was statistically analyzed and the results were presented using grounded theory analysis.

B. Quality assurance

The target population we choose for our research are expected to be professionals in specific areas to ensure reliable responses. Following the guidelines of Kasunic , the questionnaires were formed keeping in mind the different interpretations different respondents can have ,based on their knowledge ,skills and attitudes [7].

Besides taking proper care for the presentation and layout of the questionnaire, necessary corrections were made for the understandability of the questionnaire by seeking help of fellow mates. If any questions were misconceived by the respondents, then the respective responses were removed. So there are a number of challenges in implementing survey method, which have been addressed in our research to a better extent ensuring reliable results [13].

VI.   DATA ANALYSIS AND INTERPRETATION

A. DATA ANALYSIS

Since our RQ-1 and RQ-2 address the challenges in implementing CD and ensuring reliability in the deployment process, we classify the designations of the respondents obtained through the survey into 2 groups: Business and technical. We perform this classification as the challenges involved in implementing CD revolve around technical, organizational and process aspects. Based on this we have classified the 10 designations acquired through the survey as shown below in table-1

Within the time frame of the survey, we could collect 23 responses from various people with different designations. Out of these 17 responses were considered, as they were complete and were found with relevant information. As the part of survey, various parameters were considered to understand the background of the respondents. We had considered designation of the respondent and experience on their respective field (in years) as the required parameters for understanding their background.

So, the next aspect in our survey is to examine the familiarity of the respondent with the topic with various options ranging from very good to not at all.

Of the 17 qualified responses 4 opted for good, 6 for quite good, 2 for not that good and the rest for very little. Then we had considered the respondent opinion on continuous delivery, so that we can know their views on continuous delivery. Figure-3 illustrates the above aspects.

S.NO	Department	Designations
1.	Business	Business analyst, Project manager, Requirement engineer, Software designer, Team Director
2.	Technical	Technical product manager, Technical project manager, Software developer, Project leader, Software development manager.

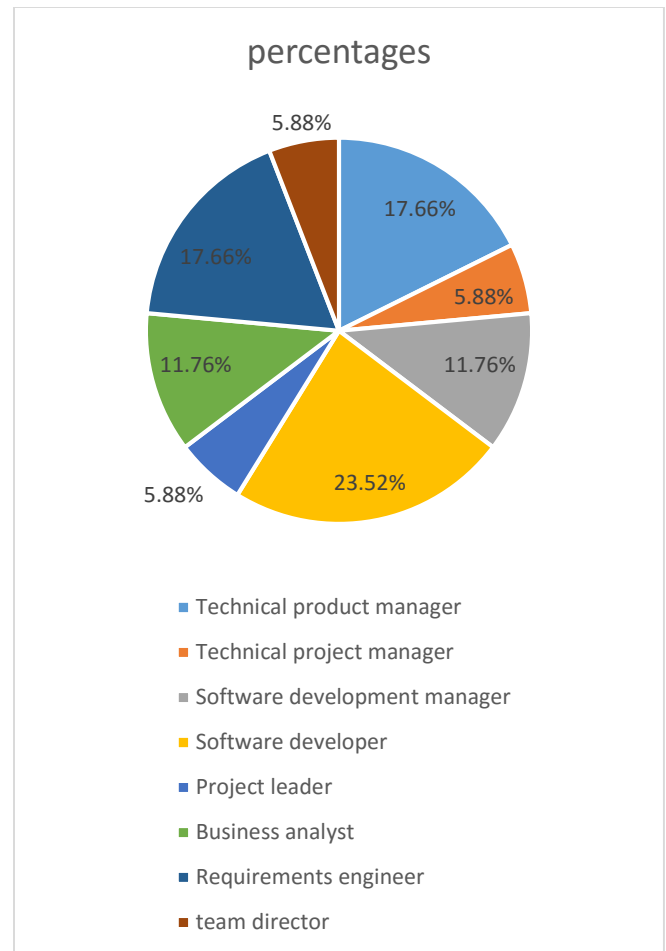**Table-1 Classifying the designations obtained**

Figure 2: Percentage representation of respondents

So, the next aspect in our survey is to examine the familiarity of the respondent with the topic with various options ranging from very good to not at all. Of the 17 qualified responses 4 opted for good, 6 for quite good, 2 for not that good and the rest for very little. Then we had considered the respondent opinion on continuous delivery, so that we can know their views on continuous delivery. Figure-3 illustrates the above aspects.
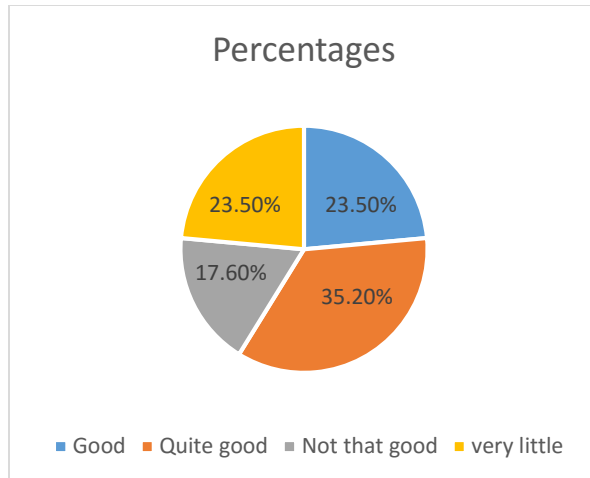
Figure 3: Percentage of respondent's knowledge in the domain

The following questions were asked in the survey.

Q1) How do we ensure reliability in Continuous Delivery process?

Q2) How to maintain customer involvement in Continuous Delivery?

As we are starters just beginning our research, usage of grounded theory in conducting qualitative research for data analysis is an appropriate method [17]. This approach is suitable for both open and close ended questions. In grounded theory, we had selected Strauss and Corbin's as a suitable approach as it is extensible in reading the data [15]. This approach consists of three types of coding which are open coding, axial coding and selective coding [16]. Methods to ensure reliability were presented after proper review and the respondents were asked to select from them. The results are presented using a bar graph in figure-4
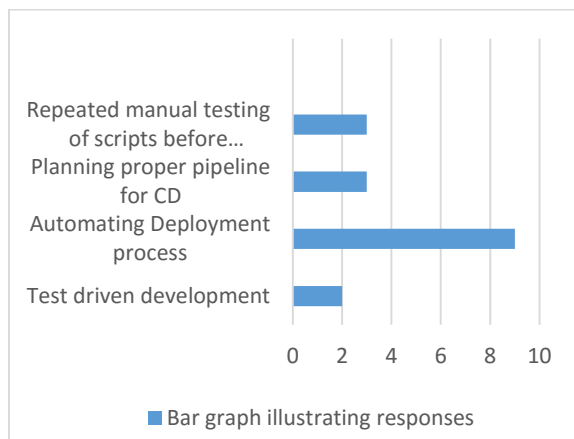

Figure-4 Responses related to RQ-2

B. INTERPRETATION

The results of the survey are interpreted in the following way to generate answers to the research questions:

RQ:1 What are the challenges in implementing CD?

- Allocating applications in the organization that are not related to CD.
- Absence of durable and customizable tools that setup the CD platform efficiently.
- There are few challenges related to the processes of business, software development and operational areas that extend the feedback cycle (time issue)
- Presence of tensions and barriers among teams in the software development organization

RQ:2 What are the challenges in ensuring reliability in CD?

We framed a closed question in the survey in order to answer this question. Positive responses were in favor of automating the deployment process due to cost-saving factor.

In this way reliability ensure minimal revenue loss. The remaining options to provide reliability like test driven development and repeated manual testing of the scripts before deploying product received negative responses and preferred less. We expect that the reason for this is time constraint and unavailability of short feedback cycles

RQ:3 How can we enhance the coordination and management of customer involvement in CD?

Customer involvement can be enhanced by the following ways:

- Balanced feedback mechanism should be encouraged to support immediate feedback from users.
- Use of social media and online data sources.
- Develop a strong and reliable relation with the customer so that he gets motivated to be a part of development process.
- Taking quick inputs and feedbacks from customer enhances the CD process

VII. DISCUSSION

A. CONTRIBUTIONS

The main contributions of our research in this field are addressing the challenges in ensuring reliability in CD and the issues involved in implementing it. Though the relevant literature in [1], [3], [6] supported reliability and improving the CD pipeline to implement CD, but they have not mentioned the

challenges involved in it. In article [6], the authors have tackled the problem of customer involvement in CD but have not provided measure to maintain and coordinate it.

Our research contributes also contributes in this aspect. The main findings of our research are:

- Organizational challenges effect the implementation of CD than process and technical aspects.
- We can achieve reliability in CD by automating the deployment process rather than the manual process addressed [4], [1].

Therefore, through our research we have been able to present a clear overview of the domain. Previous studies have not been able to overcome the shortcomings faced in implementing CD.

B. THREATS TO VALIDITY

The following validity threats to the research are identified from [14].

Analyst Bias: Since we selected grounded theory analysis to generate the results, there are no assumptions or predetermination of results i.e. no Initial hypothesis formulation. Thus analyst bias is mitigated.

Respondent's Bias: While conducting research we need to make sure that there is no external influence on the respondents while answering the questions. This can be done by ensuring anonymity.

Construct validity threats; Misconceptions regarding the questions in the questionnaire due to lack of understandability arises few threats. These threats can be mitigated by peer-reviewing the questionnaire.

Internal validity threats; The sample selected by non-probabilistic sampling might be a threat to the research as the respondents may not be associated with software delivery process. This threat can be mitigated applying exclusion criteria to remove unnecessary responses.

External validity threats; Since the survey was conducted considering a few number of people, the results might not be accurate. When we conduct the same survey on a wide and larger scale the results might be better.

Conclusion validity threats: The conclusion validity was mitigated by following systematic guidelines for conducting survey [9] and data analysis [15].

C. LIMITATIONS

1. Limited time: We might have missed out few important aspects that could have supported our research due to time constraint.
2. Limited knowledge: Since we approached limited number of people to fill the survey, the knowledge of respondents might be unreliable. Also due to our limited knowledge we might have not analyzed the data effectively.
3. Limited Resources: We might have missed different areas of professional working in different companies to participate in the research.

VIII. SUMMARY AND CONCLUSIONS

In our study, the challenges faced in customer involvement in customer delivery was addressed. Initially, a systematic literature review was conducted where it was identified that, there are some potential challenges in customer involvement in continuous delivery.

Therefore, some methods were required to enhance coordination and management in CD. Hence, the objective of the paper is to ensure reliability in CD pipelines and to address the challenges in implementing CD.

In the next phase, a survey was conducted which showed that continuous delivery is good approach for software delivery. We have conducted a survey targeting software professionals. As the part of future work, there is a need to develop strategies in order to tackle the implementation issues in CD and how customer involvement can affect CD. Due to time constraint, a case study couldn't be performed for addressing the architectural issue of CD, which can be also be used for addressing the need for architecture.

IX. REFERENCES

[1] L. Chen, "Towards Architecting for Continuous Delivery," in *2015 12th Working IEEE/IFIP Conference on Software Architecture (WICSA)*, 2015, pp. 131–134.
[2] S. Krusche and L. Alperowitz, "Introduction of Continuous Delivery in Multi-customer Project Courses," in *Companion Proceedings of the 36th International Conference on Software Engineering*, New York, NY, USA, 2014, pp. 335–343.
[3] L. Chen, "Continuous Delivery: Huge Benefits, but Challenges Too," *IEEE Softw.*, vol. 32, no. 2, pp. 50–54, Mar. 2015.

[4]   O. Akerele, M. Ramachandran, and M. Dixon, "System Dynamics Modeling of Agile Continuous Delivery Process," in *Agile Conference (AGILE), 2013*, 2013, pp. 60–63.

[5]   J. Humble and D. Farley, *Continuous Delivery: Reliable Software Releases through Build, Test, and Deployment Automation (Adobe Reader)*. Pearson Education, 2010.

[6]   S. G. Yaman, T. Sauvola, L. Riungu-Kalliosaari, L. Hokkanen, P. Kuvaja, M. Oivo, and T. Männistö, "Customer Involvement in Continuous Deployment: A Systematic Literature Review," in *Requirements Engineering: Foundation for Software Quality*, M. Daneva and O. Pastor, Eds. Springer International Publishing, 2016, pp. 249–265.

[7]   S. Easterbrook, J. Singer, M.-A. Storey, and D. Damian, "Selecting Empirical Methods for Software Engineering Research," in *Guide to Advanced Empirical Software Engineering*, F. Shull, J. Singer, and D. I. K. Sjøberg, Eds. Springer London, 2008, pp. 285–311.

[8]   G. G. Gable, "Integrating case study and survey research methods: an example in information systems," *Eur. J. Inf. Syst.*, vol. 3, no. 2, pp. 112–126, 1994.

[9]   T. Punter, M. Ciolkowski, B. Freimut, and I. John, "Conducting on-line surveys in software engineering," in *2003 International Symposium on Empirical Software Engineering, 2003. ISESE 2003. Proceedings*, 2003, pp. 80–88.

[10]   S. Looso, R. Börner, and M. Goeken, "Using grounded theory for method engineering," in *2011 Fifth International Conference on Research Challenges in Information Science (RCIS)*, 2011, pp. 1–9.

[11]   J. M. Corbin and A. Strauss, "Grounded theory research: Procedures, canons, and evaluative criteria," *Qual. Sociol.*, vol. 13, no. 1, pp. 3–21, Mar. 1990.

[12]   W. Foddy, *Constructing Questions for Interviews and Questionnaires: Theory and Practice in Social Research*. Cambridge University Press, 1994.

[13]   A. Singh, A. Taneja, and G. Mangalaraj, "Creating online surveys: some wisdom from the trenches tutorial," *IEEE Trans. Prof. Commun.*, vol. 52, no. 2, pp. 197–212, Jun. 2009.

[14]   A. M. Robert Feldt, "Validity Threats in Empirical Software Engineering Research - An Initial Survey.," pp. 374–379, 2010.

[15]   A. Strauss and J. M. Corbin, Basics of qualitative research: Grounded theory procedures and techniques. Sage Publications, Inc, 1990.

[16]   A. Strauss and J. Corbin, "Grounded theory methodology," Handbook of qualitative research. pp.273–285, 1994.

[17]   J. Hughes and S. Jones, "Reflections on the use of grounded theory in interpretive information systems research," in Proceedings of European Conference on Information Systems (ECIS), 2003, p. 62.

Appendix A

A Survey on Challenges and Customer Involvement Continous Delivery Process

* Required

Name of the Organisation *

Your answer

Designation *

Your answer

Experience *

○ 1-3 yrs

○ 3-5 yrs

○ 5-7 yrs

○ >7 yrs

○ 5-7 yrs

○ >7 yrs

Rate your experience on Continuous Delivery process *

○ Very Good

○ Good

○ Quite Good

○ Not that good

○ Very Little

○ Not at all

Do you consider continuous delivery process as good approach for software delivery? *

○ Yes

○ No

○ May Be

○ Don't Know

○ Yes

○ No

○ May Be

○ Don't Know

What are the challenges in implementing CD?

Your answer

Please provide an argument for your answer

Your answer

How do we ensure reliability in Continuous Delivery process?

☐ Automating deployment process

☐ Repeated manual testing of scripts before deploying

☐ Planning proper pipeline for CD

☐ Test driven development

☐ Other: _____

How do we ensure reliability in Continuous Delivery process?

☐ Automating deployment process

☐ Repeated manual testing of scripts before deploying

☐ Planning proper pipeline for CD

☐ Test driven development

☐ Other: _____

How do we maintain customer involvement in Continuous Delivery?

Your answer

SUBMIT   ━━━━━━━━━━━ 100%: You made it.